UDC 633.2:631.8

Productivity and feeding value of Lucerne as compared to other perennial grasses

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The purpose. To determine the best perennial leguminous grasses at organic and mineral fertilizing and perfection of technological measures of production of feed raw material with continuous uniform receipt of vegetable mass for manufacture of ecologically safe grassy feedstuffs on dark grey podzolized soils. Justification of norms and ratios of basic nutrient elements of fertilizers for Lucerne-cereal grass stand, features of its conversion depending on fertilizer systems, use and development of measures of rational application of solid mineral fertilizers on meadow lands in conditions of northern part of Forest-steppe of Ukraine. **Methods.** Systems analysis, field, laboratory, analytical, mathematical-statistical, calculative-comparative. **Results.** The basis of botanical content of single-species sowings of perennial leguminous grasses made sowed crops. Perennial leguminous grasses in the first 3 years of use essentially predominated as to their productivity over grass family — brome grass. Productivity of leguminous grasses without fertilizers made 9 – 12 t/hectare of dry mass, 7 – 9 t / hectare of f.u., 90 – 103 GJ/hectare of exchange energy. Perennial leguminous grasses accumulated in above-ground vegetable mass on the average 155 – 302 kg/hectare symbiotically fixed nitrogen for 3 years of use of grass stands. Growing of perennial leguminous grasses with the purpose of production of grassy feedstuffs is economically efficient as even without fertilization they ensured deriving about 7724 – 9803 hrn/hectare of conditionally-net profit at cost price of 546 – 630 hrn/1 t of f.u. with the level of profitableness 165 – 205 %. **Conclusions.** The highest productivity had the grass stand with Lucerne. The greatest accumulation of symbiotically fixed nitrogen had Lucerne, which indexes of economic efficiency were the highest. Most economically expedient was importation of preparation Wuxal-Microplant.

Key words: *leguminous grasses, Lucerne, fertilizers, fixed nitrogen, economic efficiency.*

DOI: https://doi.org/20.31073/agrovisnyk201910-04

The production of cheap milk and meat, especially for diet and baby food, is directly dependent on the production of high-quality herbal feed for cattle. The leading role in fodder production is the cultivation of perennial bean grasses and bean-cereal mixtures, as well as optimization of measures for their cultivation. Today, the development of agricultural production in Ukraine requires the introduction and development of the latest technologies, modern forms of management, as demanded by the market. Therefore, the most efficient system of management is low-cost energy and resource-saving, which is due to the cultivation of perennial legumes and bean-cereal mixtures.

The purpose of the work is to establish the best perennial legume grass for organic and mineral fertilizers and to improve the technological measures for the production of feed raw materials with a continuous uniform supply of plant matter for the production of environmentally safe herbal feed on dark gray podzolic soils, as well as in the determination of ecologically based doses and the ratios of the main nutrient elements of mineral fertilizers for alfalfa-cereal grass, the peculiarities of its transformation depending on fertilizer systems and the use and development of measures for the rational use of mineral fertilizers on meadow lands in the conditions of the Northern part of the Forest-steppe of Ukraine.

Research methodology. The research on the study of the regularities of the formation of the productivity of perennial legumes in the system of green raw material conveyors for the organic production of feed raw materials was carried out by the State Enterprise «Research farm» Chabany «at the NSC» Institute of Agriculture of NAAS «on a dark gray podzolized soil according to commonly accepted methods of fodder production.

In an experiment to study the comparative productivity of different species of perennial legumes, the study was conducted on three fertilizer backgrounds according to the scheme. The drug «Wuxal-Microplant», which represents a mixture of macro-and trace elements in chelate form, was introduced by spraying the above-ground mass into the phase of planting grasses in the 1st mowing in a dose of 2 l/ha. In the cereal grass additionally, nitrogen fertilizers were added at a dose of N_{90}, which was administered in two steps.

The next experiment is laid out in the spring on the alfalfa-cereal grass in the third year of the use of hay bunches of normal moisture with dark gray linden soils. The research was carried out at the State Enterprise «Institute of Agriculture of the Chabany» of the NSC «Institute of Agriculture of NAAN» according to generally accepted methods for fodder production [1, 2].

Phosphate fertilizers, regardless of the mode of use, are introduced in one date of spring. Potassium fertilizers are introduced in two terms in equal quantities under the first (in the spring) and the second (after the first alienation of the grass) mowing. Nitrogen fertilizers were applied evenly under each mowing in experiment 1 in 3 lines (on N_{30} and N_{60}), in experiment 2 for haymaking in two terms (by N_{70}), and in multi-mowing ones – in four (at N_{35} for the first four cycles of use).

Research results. Long-standing legumes are characterized by potentially high productivity, in which the content of digestible protein can reach up to 200 g or more in one feed unit. Due to its biological features, legumes in symbiosis with tuberous bacteria can capture 300-500 kg / ha of nitrogen from the air, thereby enriching the soil with biological, extremely important, nitrogen from 150 to 300 kg / ha [3, 4, 5].

Symbiosis (Greek «symbiosis» – compatible life) is a unique phenomenon of nature in the plant world, where there is a joint life of legumes and bulbous bacteria, during which a complex process of biological fixation of air nitrogen is carried out by microorganisms [6, 7].

From the point of view of fodder production, this is an extremely important process, since nitrogen is fixed near the root systems, where the part of ammonium formed as a result of fixation used microsymbionts for its growth and development, but most of it is exported to the cells of host plant [6, 8].

Perennial grasses are very valuable forage crops, especially for the green conveyor, among which the most common is alfalfa. Alfalfa is one of the oldest forage crops. It is a high-yielding, winter-hardy and drought-resistant crop. More than 50 species of alfalfa have been studied, but only 2 species have acquired production values – purple medic (*Medicago sativa* L.) and sickle alfalfa (*Medicago falcata* L.) [9, 10].

To solve the problem of providing feed with valuable proteins, legumes are sown, especially alfalfa, which provides for the annual use of 400-500 centner per ha of green mass and 80-100 centner per ha of dry matter.

Nutritionally, the green mass of alfalfa is a very valuable, high-vitamin and dietary food. The content of protein and digestible coefficient of green mass of alfalfa exceeds all cereals and all legumes perennial grasses. The digestibility coefficient reaches 75%, and the content of crude protein is 18-20% in dry weight [11-13].

By results of researches it is seen that the basis of the Botanical composition of sown perennial grasses during the first three years after sowing amounted to purple medic, bird's-foot and awnless brome with a share of sowed crop in an average of three years 84 to 97 %, depending on the options of fertilizers, which characterizes them as a culture of high productive longevity. Better herbage preserved in purple medic and amounted to 90-98 % of the total yield (table 1).

Experimental plots laid in the spring with the sowing of herbs under the cover of barley in 2011. Studied comparative productivity of different species of perennial grasses, particularly red clover, variety – Polianka, a bird's-foot, variety – Ajax, purple medic, variety – Olga, sickle alfalfa, variety – Narechena Pivnochi in comparison with Gramineae grass stand (awnless brome, variety – of Arsen).

The analysis of the results of studies on the regularities of the formation of productivity showed that perennial legumes significantly exceed the productivity of cereal perennial grass awnless brome (table 2).

The gathering of fodder units and crude protein, and gross output and exchange of energy, over the years of using perennial leguminous herbs and awnless brome depended both on the species composition of herbage and options of fertilizer (table 3).

On average over 2012-2014, the gathering of fodder units in perennial legumes and cereal mixtures ranged from 4.36 to 10.34 t/ha, crude protein – 0.57-of 2.66 t/ha, the accumulation of gross energy from 99,1 to 203,7 GJ/ha of metabolizable energy from 54,0 up of 120.7 GJ/ha. the Highest performance for the gathering of fodder units (8.86-of 10.34 t/ha) and crude protein (2.23-of 2.66 t/ha) was provided by purple medic. Behind the pile of gross (171.9-203.7 GJ/ha) and exchange (101.9-120.7 GJ/ha) energy, purple medic was also noted.

1. ***Botanical composition of perennial grasses harvest depending on their species composition and fertilizer, %***

Type of perennial grasses	Fertilizers	Botanical composition, %						Average per 2012 – 2014	
		2012		2013		2014			
Red clover	without fertilizers (kontrol)	87	13	93	7	29	71	70	30
	Wuksal	91	9	95	5	32	68	73	27
	$P_{45}K_{90}$	95	5	96	4	34	66	75	25
Birds-foot trefoil	without fertilizers	82	18	88	12	84	16	85	15
	Wuksal	85	15	91	9	86	14	87	13
	$P_{45}K_{90}$	92	8	94	6	91	9	92	8
Purple medic	without fertilizers	90	10	94	6	92	8	92	8
	Wuksal	93	7	97	3	94	6	95	5
	$P_{45}K_{90}$	96	4	98	2	96	4	97	3
Sickle medic	without fertilizers	89	11	92	8	90	10	90	10
	Wuksal	91	9	93	7	91	9	92	8
	$P_{45}K_{90}$	94	6	95	5	93	7	94	6
Awnless brome	without fertilizers	85	15	86	14	82	18	84	16
	Wuksal	88	12	88	12	85	15	87	13
	$P_{45}K_{90}$	97	3	94	6	89	11	93	7
	N_{90}	99	1	98	2	94	6	97	3

2. ***Productivity of perennial grasses and smooth brome-grass in dependence on fertilizers, t/ha***

Type of perennial grasses	Fertilizers	Green mass productivity for three years, t/ha				Yield of dry substance for years, t/ha			
		2012	2013	2014	average	2012	2013	2014	average
Red clover	without fertilizers	52.8	45.8	36.1	44.9	12.14	9.14	8.29	9.86
	Wuksal	60.8	55.5	38.6	51.6	13.98	11.23	8.68	11.30
	$P_{45}K_{90}$	63.3	53.5	40.5	52.4	14.56	9.69	8.31	10.85
Birds-foot trefoil	without fertilizers	33.2	35.8	45.0	38.0	8.14	8.25	10.35	8.91
	Wuksal	36.2	39.0	48.5	41.2	8.92	8.42	11.15	9.50
	$P_{45}K_{90}$	35.7	39.8	51.3	42.3	9.55	8.34	11.80	9.90
Purple medic	without fertilizers	47,5	54,0	54,8	52,1	10,84	12,35	12,60	11,93
	Wuksal	53.6	65.5	57.0	58.7	12.31	15.03	13.11	13.48
	$P_{45}K_{90}$	56.3	64.5	60.8	60.5	13.42	15.33	13.98	14.24
Sickle medic	without fertilizers	42.9	38.5	52.0	44.5	9.40	8.27	11.96	9.88
	Wuksal	46.4	39.3	55.8	47.2	9.86	8.26	12.83	10.32
	$P_{45}K_{90}$	49.1	40.0	63.8	51.0	9.83	8.39	14.67	10.96
Awnless brome	without fertilizers	21.1	23.0	28.5	24.2	4.74	4.98	6.55	5.42
	Wuksal	24.3	25.0	30.0	26.4	5.58	5.77	6.90	6.08
	$P_{45}K_{90}$	23.5	28.5	34.0	28.7	5.02	6.65	7.82	6.50
	N_{90}	35.2	48.3	56.0	46.5	7.48	11.11	12.88	10.49
$\overline{X} \pm S\overline{x}$		38.8 ±2.6	43.5 ±3.2	50.9 ±2.8	44.4 ±2.7	8.8 ±0.6	9.5 ±0.7	11.7 ±0.6	10.0 ±0.6
V, %		27	29	22	24	27	31	22	24
$LSD_{0.05}$, t/ha by factors:									
Perennial grasses		3.2	3.1	3.9	3.4	0.51	0.49	0.55	0.52
Fertilizer		2.5	2.6	2.7	2.6	0.42	0.40	0.44	0.42
The share of factors in the formation of productivity,%									
Perennial grasses		57	59	56	57	66	57	59	61
Fertilizer		43	41	44	43	34	43	41	39

Note: $\overline{X} \pm S\overline{x}$ – average for experiment, 2012-2014;

V – inequality of productivity, expressed by the coefficient of variation, %

*3. **Fodder productivity of perennial leguminous grass and awnless brome grass depending on fertilizer, average for 2012-2014***

Type of perennial grasses	**Fertilizers**	**Feed unit, t/ha**	**Crude protein, t/ha**	**Gross energy, GJ/ha**	**Exchange energy, GJ/ha**
Red clover	without fertilizers (control)	7.45	1.70	163.5	88.8
	Wuksal	8.72	2.02	192.1	104.1
	$P_{45}K_{90}$	8.20	1.91	182.1	98.6
Birds-foot trefoil	without fertilizers	7.58	1.54	163.9	89.4
	Wuksal	7.93	1.72	174.1	94.6
	$P_{45}K_{90}$	8.26	1.79	181.7	98.6
Purple medic	without fertilizers	8.86	2.23	171.9	101.9
	Wuksal	9.87	2.57	193.3	114.2
	$P_{45}K_{90}$	10.34	2.66	203.7	120.7
Sickle medic	without fertilizers	8.75	1.71	174.0	102.5
	Wuksal	8.94	1.76	179.9	105.7
	$P_{45}K_{90}$	9.21	1.98	185.1	108.6
Awnless brome	without fertilizers	4.36	0.57	99.1	54.0
	Wuksal	4.90	0.69	111.4	60.6
	$P_{45}K_{90}$	5.29	0.80	119.6	65.1
	N_{90}	8.40	1.43	192.8	104.5
$\overline{X} \pm S\overline{x}$		7.94 ± 0.43	1.69 ± 0.15	168.01 ± 7.73	94.49 ± 4.77
V, %		21,6	35.5	18.4	20.2

Also, one of the important qualitative properties of perennial legumes is the ability to synthesize and accumulate available to plants symbiotically fixed nitrogen.

In order to reduce total energy consumption, leguminous grass, which partially replace mineral nitrogen with a symbiotic, which is an important constituent, as supplementing the reserve for cost reduction, is to be used in herbage plants [14, 15].

Abroad were implemented the latest energy-saving technologies for the production of animal feed. One of the ways of its solution is the introduction of a much larger number of legume species in grass, which is an integral part of any bean-and-cereal herb [16, 17, 18].

According to the results of our researches, it was found that perennial legume grasses were accumulated in plant tops, on the average over three years of use of herbaceous plants of 155 – 302 kg/ha of symbiotically fixed nitrogen. The biggest part symbiotically fixed nitrogen was accumulated in the purple medic, namely in the range from 265 – 302 kg/ha (Fig. 1), which is 1.3-1.8 times or 88 – 120 kg/ha more than in the red clover, in which he was at 177 – 213 kg/ha.

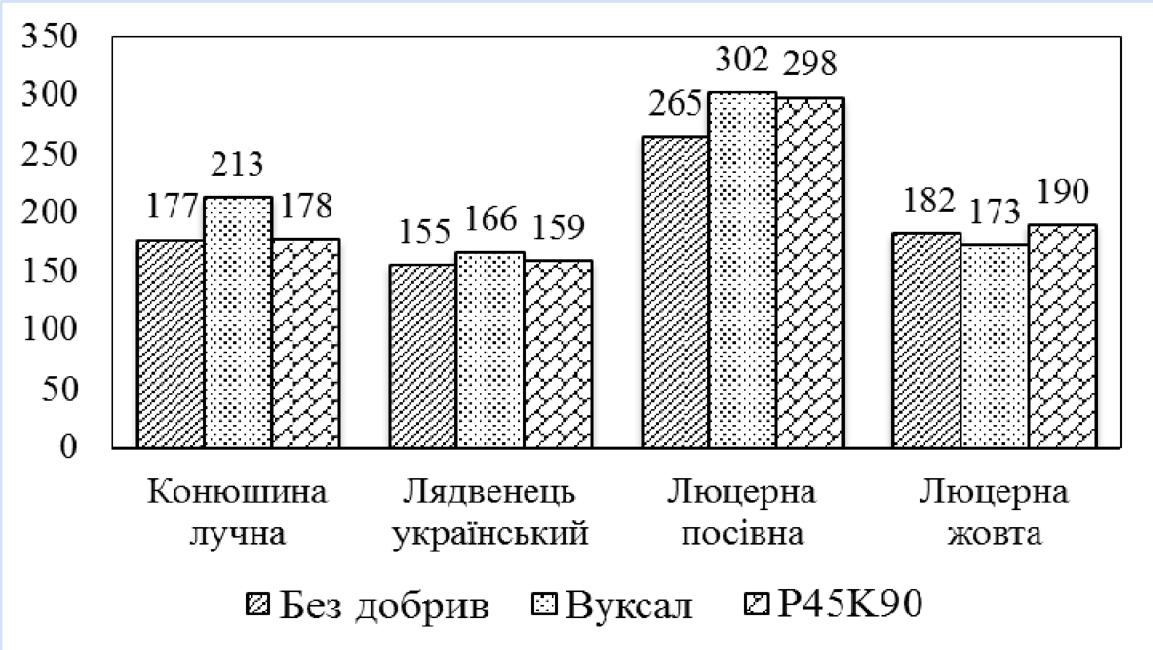

Fig. 1. Accumulation of symbiotically fixed nitrogen with legumes, average for 2012 – 2014, kg/ha

According to the data (experiment 2) the productivity of alfalfa and cereal grass, depending on the dose and ratios of the NPK of mineral fertilizers, it was found that the yield of 1 g of feed units, crude protein, gross and exchange energy increased with the introduction of nitrogen fertilizer on the background of phosphorus and potassium, and with full mineral fertilizers. Thus, on sites fertilized with nitrogen fertilizer at a dose of N_{90}, productivity indicators on average were higher in 1.1 – 1.5 times compared with the variants without the introduction of nitrogen fertilizer; on sites with N_{180} – in 1.2 – 1.7 times. The best productivity indicators at the exit from 1 hectare were in variants with full mineral fertilizers in the highest doses of $N_{180}P_{60}K_{120}$: feed units – 8.97 t/ha, gross energy – 228.8 GJ/ha, exchange energy – 93.8 GJ/ha, and the output of the crude protein was greatest on the options without the addition of potassium fertilizers – $N_{180}P_{60}$ – 2.24 t/ha.

*4. **Productivity of alfalfa-cereal grass depending on dose and ratio of NPK mineral fertilizers and regimes of use according to general indicators***

Fertilizer	Feed units, t/ha	Crude protein, t/ha	Gross energy, GJ/ha	Exchange energy, GJ/ha
Without fertilizers	5.25	1.25	128.2	54.7
K_{120}	5.49	1.26	138.2	57.8
P_{60}	5.77	1.34	141.5	60.4
$P_{60}K_{120}$	5.53	1.38	147.1	58.0
$P_{30}K_{60}$	5.76	1.31	144.6	73.8
N_{90}	7.22	1.73	184.4	75.6
$N_{90}K_{120}$	7.19	1.86	191.6	75.4
$N_{90}P_{60}$	7.64	1.80	194.3	79.6
$N_{90}P_{60}K_{120}$	7.73	1.85	200.6	80.6
$N_{90}P_{30}K_{60}$	7.57	1.84	197.2	79.2
N_{180}	8.36	2.00	215.2	88.2
$N_{180}K_{120}$	8.73	2.08	221.5	90.8
$N_{180}P_{60}$	8.73	2.24	224.5	91.9
$N_{180}P_{60}K_{120}$	8.97	2.10	228.8	93.8
$N_{180}P_{30}K_{60}$	8.89	2.14	226.5	92.8
$LSD_{0,05}$	0.32	0.11	3.6	1.3

In the alfalfa-cereal grass, high, approximately the same, the indices of the level of compensation of mineral nitrogen were symbiotic were obtained in the first three years for hay application on a dry basis (Table 5). In the last year the indices has decreased 1.7 times. In terms of crude protein for haymaking, the level of compensation for the second and third years was the same – 150 kg/ha, in the last year there was a decrease of 83 kg/ha. For multi-mowing use, the indicator of compensation level on dry weight basis over the years of use of herbage increased and in the last year was 176 kg/ha, which is 1.4 times less than the first.

In the calculation of the same for the raw protein, it was the largest in the third year – 233 kg/ha, and the smallest in the second year – 120 kg/ha. According to the summary data, the indicator of the level of compensation of mineral nitrogen by symbiotic alfalfa and cereal grass was found to be higher on the crude protein – 125 – 165 kg/ha, which is 1.1-1.4 times more than in dry weight.

*5. **Level of compensation of mineral nitrogen by symbiotic seedlings of bean-and-cereal grass on the background of $P_{60}K_{120}$, kg/ha (2003-2006)***

Forage	Years				Middle
	2003	2004	2005	2006	
On a dry basis					
Hay mowing usage					
Alfalfa-cereal	102	103	103	60	92
Multi-mowing usage					
Alfalfa-cereal	127	115	167	176	146
On a crude protein basis					
Hay mowing usage					
Alfalfa-cereal	133	150	150	67	125
Multi-mowing usage					
Alfalfa-cereal	133	120	233	175	165

Based on the results of three years of research (experiment 1) and the obtained data, taking into account the developed technological cards for all processes of growing and calculating all costs for technological operations (wages, fuel and lubricants, depreciation, costs for seeds and fertilizers, etc.) and economic calculations for prices in 2015 proved that the economic efficiency of growing perennial legumes was quite high, as evidenced by the high level of profitability. The combined costs of growing perennial legume grasses on average in 2012 – 2014 ranged from 4692 to 13368 UAH/ha, which is 944 – 1.494 UAH/ha more than a awnless brome, where the costs were in the range from 3748 – 11874 UAH/ha.

The largest expenditures were on alfalfa seedlings (5107 – 13368 UAH/ha), which has a direct dependence on the high yield of this crop, and hence the cost of production (14767 – 17233 UAH/ha), conditionally net profit (3865 – 10308 UAH/ha) and the level of profitability (29 – 189%) were also the highest, and the cost of 1 t of feed units (576 – 1293 UAH) was the smallest.

Conclusions

The basis of the botanical composition of single-species crops of perennial legume grasses were sown crops of the red clover, birds-foot trefoil, alfalfa, purple medic and sickle medic with a share of 82 – 99%. The best of herbs is preserved in the alfalfa of seedlings and a awnless brome for the introduction of N_{90}*, which are well kept for three years.*

Perennial legumes in the first three years of use had a significant prevalence of productivity than cereals and awnless brome grass forage. The productivity of legumes without fertilizers ranged from 9-12 t / ha of dry weight, 7-9 t/ha of fodder units, 90-103 GJ / ha of exchange energy. The highest productivity of different grass stands was a purple medic, which is 1.2 times higher than red clover and sickle medic, in 1.8 times − the birds-foot trefoil, and 2.5% awnless brome. Introduction of the preparation Wuksal-Microplant increased the productivity of perennial grasses by 0.6-1.5 t/ha, and $P_{45}K_{90}$ *− by 1.0-2.3 t/ha of dry weight.*

Perennial legumes accumulated in the above-ground plant mass in an average of three years of use of 155-302 kg/ha of symbiotically fixed nitrogen. The greatest accumulation of symbiotically fixed nitrogen had purple medic sowing, which is 1.3-1.8 times more compared to other legumes.

In the second experiment from alfalfa-cereal stand better productivity indicators for output with 1 ha were variants with full mineral fertilizer in high doses $N_{180}P_{60}K_{120}$ *with a sufficiently high level of compensation of mineral nitrogen by symbiotic.*

The cultivation of perennial legumes for the production of herbal feed is cost-effective, even without fertilizer provided with 1 hectare 7724-9803 UAH conditionally net income at the cost of 1 ton of feed units 546-630 UAH with a level of profitability of 165-205 %. The highest rates of economic efficiency provided purple medic sowing. Among the fertilizers most economically feasible is the introduction of the preparation Wuxal-Micropland that to ensure that from the 1 hectare on purple medic we can obtain to 10308 UAH/ha conventionally net profit with the cost price of 1 ton of feed units 622 UAH and level of profitability 168%.

References

1. Babych, A.O. (1994). *Metodyky provedennia doslidiv po kormovyrobnytstvu* [Methods of conducting experiments on fodder production]. Vinnytsia. (in Ukrainian).

2. Dospekhov, B.A. (1985). Metodyka polevoho opyta [Methodology of field experience]. Moscow. Ahropromyzdat. (in Russian).

3. Demydas, H.I., Kvitko, H.P., & Tkachuk, O.P. (2013). *Bahatorichni bobovi travy, yak osnova pryrodnoi intensyfikatsii kormovyrobnytstva* [Perennial legumes as a basis for natural intensification of forage production]. Kyiv. Tsentr uchbovoi literatury. (in Ukrainian).

4. Kurhak, V.H., & Tsymbal, Ya.S. (2015). Vyroshchuvannia kormovykh kultur za orhanichnoho zemlerobstva [Growing fodder crops in organic farming]. *Bulletin of Agricultural Science*, *6*, 5–9 (in Ukrainian).

5. Kurhak, V.H., & Tsymbal, Ya.S. (2015). Osoblyvosti vedennia kormovyrobnytstva za orhanichnoho zemlerobstva [Features of management of fodder production in organic farming]. *Proceedings of the Scientific Research Center of the NAAS Institute of Agriculture*, *3*, 77–86 (in Ukrainian).

6. Babych, A.O. (1993). *Problema bilka i vyroshchuvannia zernobobovykh na korm* [The problem of protein and growing legumes forage]. Kyiv. Urozhai. (in Ukrainian).

7. Patyka, V.P., & Petrychenko, V.F. (2004). Mikrobna azotfiksatsiia u suchasnomu kormovyrobnytstvi [Microbial nitrogen fixation in modern fodder production]. *Feed and feed production*, *53*, 3–10 (in Ukrainian).

8. Trepachev, E.P., Yahodyna, M.S., & Azarov, B.F. (1991). Orhanycheskoe veshchestvo y azot bobovykh v zemledelyy Tsentralno-chernozemnoho raiona: vklad v plodorodye pochvy y potrebnost v azotnom udobrenyy posleduiushchykh kultur [Legume organic matter and nitrogen in the agriculture of the Central Black Earth Region: contribution to soil fertility and the need for nitrogen fertilizer in subsequent crops]. *Agricultural biology, 5*, 16–30 (in Russian).

9. Zharynov, V.Y., & Kliui, V.S. (1990). *Liutserna* [Alfalfa]. Kyiv. Urozhai. (in Ukrainian).

10. Kalashnyk, D.I. (1969). *Liutserna – tsinna kormova kultura* [Lucerne is a valuable forage crop]. Kyiv. Urozhai. (in Ukrainian).

11. Makarenko, P.S. (1984). *Dovidnyk z kormovyrobnytstva* [Handbook of forage production]. Kyiv. Urozhai. (In Ukrainian).

12. Bohovin, A.V., & Kurhak, V.H. (1990). Vydovi osoblyvosti bahatorichnykh trav i yikh vplyv na formuvannia vysokoproduktyvnykh siianykh travostoiv [Specific features of perennial grasses and their influence on the formation of high-yielding sown grasses]. *Herbage crops are the basis of forage production: theses of supplement of sciences pomegranate.* Vilnius. P. 19–21 (in Ukrainian).

13. Metodyka bioenerhetychnoi otsinky tekhnolohii vyrobnytstva produktsii tvarynnytstva i kormiv [Technique of bioenergy evaluation of livestock and feed production technologies]. (1997). Vinnytsia. (In Ukrainian).

14. Doyle, C.J. (1985). An agro-economic review of grass and other forage cross. *British crop Protection Conference weeds, 2*, 725–729.

15. Kahnt, G. (1982). Potential legumes in temperate climate. National Symposium on Biological Nitrogen Fixation. Helsinki, *2*, 207–218.

16. Yates, A. (1983). Reduce your nitrogen bill. *Big Farm Management*. September, 19–20.