СІЛЬСЬКОГОСПОДАРСЬКІ НАУКИ

УДК 633.31 **DOI**: 10.31521/2313-092X/2020-4(108)-3

FORMATION OF THE ALFALFA VARIETY PRODUCTIVITY FOR HAY IN THE STEPPE OF SOUTHERN UKRAINE

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The results of research on the formation of productivity of alfalfa varieties for hay in non-irrigated agrophytocenoses under conditions of global warming in the steppe of southern Ukraine are presented. It was found that some varieties zoned in Ukraine are more adapted to the arid conditions of the southern steppe and therefore more productive (5.5-11.7% in hay harvest) compared to control plants (Nadezhda variety - hay yield on average for four years of alfalfa life amounted to 2.84 t / ha).

***Keywords**: alfalfa, variety, weather conditions, hay, productivity.*

Formulation of the problem. It is generally accepted that perennial grasses are an important component in animal nutrition. At the same time, in recent years the production of all fodder crops, including high-protein legumes, has decreased.

Alfalfa is one of the most common forage crops that can improve the condition of the forage base to provide animals with the necessary proteins and at the same time affect the level of biologization of agriculture, improve (or at least maintain) soil fertility. It is in great demand in the market of perennial herbs. It is sown both in mixtures and independently [1-4].

Analysis of recent research and publications. Many studies have been conducted to identify measures to improve alfalfa productivity. Scientists from the Institute of Feed and Agriculture of Podillya NAAS and Vinnytsia National Agrarian University have investigated that weather conditions have a significant impact on the content and ratio of structural carbohydrates in the green mass of alfalfa. These alfalfa feeds have no equal in terms of nutrients and biologically active substances [3].

According to Yulia Nazarenko [5], in the field of agriculture, the production of alfalfa fodder is a very profitable business. Under the conditions of application of scientifically grounded technologies, agrarians provide high productivity of a plant within 4-6 years.

The productivity of alfalfa plants can be increased through the use of the growth-regulating drug Emistim C for pre-sowing seed treatment [6].

Scientists of Bila Tserkva NAU emphasize that alfalfa leaves have a much more valuable composition compared to the stems. It contains about 80% protein and carotene and about 70% of the most important mineral elements [7].

It is calculated that the cost per feed unit of green mass of alfalfa is the lowest compared to other types of feed [3].

At the same time, according to Kovalenko V.P. [8], the model of growing alfalfa for green fodder without fertilizers is optimal in terms of cost savings (2771 UAH/ha), while the most expensive is the technology, which uses $N_{90}P_{90}K_{120}$ (4661 UAH/ha).

An important factor in obtaining high yields of green mass, and hence hay grass, is moisture. The highest yields of hay of perennial grasses, including alfalfa, are collected in Ukraine in areas of sufficient moisture [9, 10].

However, in the South of Ukraine, under conditions of low moisture supply, insufficient research has been conducted to determine the most effective measures to increase forage productivity of alfalfa, in particular the optimization of varietal composition..

There are more than 50 varieties of alfalfa, but only a few are widespread in Ukraine [5].

At present, edaphic selection methods are increasingly used in the creation of alfalfa varieties [11].

We have repeatedly emphasized that alfalfa should play an important role in field grass sowing. At the same time, in terms of management in the southern steppe of Ukraine, it is important to grow

varieties that are resistant to drought, which is increasingly observed in recent years.

The aim of the study - determining the influence of weather conditions on the formation of the harvest of alfalfa varieties on hay under conditions of natural moisture in the southern steppe of Ukraine to identify the most drought-adapted varieties valuable high-protein culture.

Materials and methods of research. Studies to determine the productivity of alfalfa varieties (intended for haymaking), to identify the most adapted to arid conditions, were conducted in the south of Ukraine (a branch of the Nikolaev National Agrarian University). The relief of the soil under the experiment was flat. Soil-southern chernozem residual weakly saline, heavy loam on the carbonate forest. The content of humus according to Tyurin (in a layer of 0-30 cm) is 2.9%. The reaction of the soil solution is close to neutral: the pH of the salt extract is 6.6-6.8. 100 g of soil contains an average of 1.2 mg of nitrates, 8.5 mg of mobile phosphorus and 18 mg of exchangeable potassium.

The density of the soil layer 0-60 cm is 1.25 g/cm^3, HB – 23.5%, wilting moisture – 11.4%. Groundwater lies deeper than 20 m and does not affect the process of soil formation. An average of 400 mm of precipitation falls per year, and the hydrothermal coefficient is 0.7-0.8. The average height of snow cover is 6-8 cm, and the average reserves of productive moisture in the soil layer 0-100 cm in the spring are 130 mm.

The experiments used sowing material of alfalfa varieties, the originators of which are scientists of the Institute of Irrigated Agriculture NAAS (Vavilovka 2, Veselka, Nadezhda, Unitro), Breeding and Genetic Institute – National Center for Seed Science and Variety Studies NAAS (Laska, Lyuba, Nasolodov, Inselodov, Nasiloda) farms of Podillya NAAS (Regina).

Alfalfa was grown according to the generally accepted technology for the zone. Predecessor – winter barley. Sow alfalfa of the studied varieties by ordinary row way April 3, 2015. Seed wrapping depth 2-3 cm. Alfalfa sowing rate is 9 million similar seeds per 1 ha. Before sowing and after sowing, the soil was rolled under sowing.

Care for alfalfa crops in the second, third and fourth years of life included early spring harrowing with a cultivator KShP-8. Collected leaf mass for hay during budding-early flowering.

Yield was determined by weighing as the number of replicates according to the method [12–14]. Processing of the received information and results of research was carried out by means of software packages: Microsoft Excel, Agrostat New.

Presenting main material. According to the above data, weather and climatic conditions for growing alfalfa for various purposes in the South of Ukraine are satisfactory, so its seeds are in great demand compared to other perennial grasses. Thus, its areas are allocated larger areas compared to other grasses (65.8% in the structure of sown areas for grass seeds in 2016, 89.2% – in 2017 (Table 1).

Table 1

Production of perennial grass seeds on non-irrigated lands Of the South of Ukraine (on an example of the Nikolaev area [15])

2016			2017			2018		
The area is collected, thousand hectares	Gross collection, t	Yield, t/ha	The area is collected, thousand hectares	Gross collection, t	Yield, t/ha	The area is collected, thousand hectares	Gross collection, t	Yield, t/ha
Seeds of perennial grasses (total)								
0.38	174.1	0.46	0.37	99.7	0.27	0.19	947	0.49
including alfalfa								
0.25	88.6	0.35	0.33	20.4	0.06	c *	c	c
sainfoin								
0.121	84.2	0.69	0.04	78.3	1.91	c	c	c
other perennial grasses								
0.004	1.3	0.33	0.003	0.94	0.31	0.04	1.2	0.30

*Note: * c - information is confidential.*

The gross harvest of alfalfa seeds (88.6 tons), obtained in 2016, was sufficient for sowing (88,600 kg: 20 kg/ha) on an area of 4430 hectares. As for sainfoin, the volume of harvested seeds (84200 kg: 100 kg/ha) was only enough for 842 ha. Regarding the structure of areas harvested for seeds in 2017, the advantage, as already emphasized above, was also alfalfa.

Thus, the main crop among the small variety of perennial grasses in the arid conditions of the southern steppe is alfalfa. Fluctuations in its productivity are quite different over the years and depend significantly on weather conditions. If in farms of all categories in 2018 the seed yield was 0.49 t/ha, in 2017 it did not exceed 0.27 t/ha. Undoubtedly, the abiotic limiting factor in the cultivation of alfalfa in southern Ukraine is moisture.

During the study period, the plants in the initial period of growth and development were best supplied with moisture due to precipitation in 2018. In March, their number was 75.5 mm at a rate of 18.0 mm. In addition, 289.0 mm of rain fell in April-September, which is 49.0 mm more than normal. In 2015, ie in the year of alfalfa sowing, these figures were much lower (64.0 mm in March and 186.1 mm in April-July). Insufficient precipitation was also noted in 2017: 4.3 mm in March at the rate of 18.0 mm, 19.9 mm in June at the rate of 54.0 mm and 192.0 mm - in April-July at the rate of 240.0 mm .

Researchers have found that in the southern steppe of Ukraine plants use only about 24-25% of summer rainfall, and with a monthly rainfall of less than 25 mm, this moisture completely evaporates [16].

Important for the growth and development of grasses are the reserves of productive moisture, which in arid conditions accumulate, mainly during the autumn and winter months. During sowing (in 2015) in the meter layer of soil moisture reserves were formed at the level of 142 mm (optimal). As of March 10, 2016, the moisture content of the meter layer under alfalfa crops in the second year of life was satisfactory - 112 mm. However, in 2017, the reserves of productive moisture in the 0-100 cm layer of soil were 148 mm, which corresponds to optimal moisture. At the same time, agrometeorological conditions of the 3rd decade of March 2017 were unfavorable for the vegetation of alfalfa of the third year of life. Thus, due to dry and windy weather, there was a rapid consumption of much-needed for plants productive moisture from both arable (0-30 cm) and meter-long soil layers. In 2018

The reserves of productive moisture (as of April 9, 2018) in the meter layer were optimal (145 mm) for alfalfa plants of the fourth year of life.

It is advisable to analyze the temperature regime that developed during the growing season in alfalfa agrophytocenoses.

According to scientists, temperature is an important abiotic factor. It limits the growth and development of plants because it affects the rate of cell division, the intensity of cellular metabolism and photosynthesis. The rate reactions of photosynthesis also depend on the temperature regime. They control various metabolic pathways [17, 18, 19].

The hottest growing season was in 2018. The average daily air temperature in April-September averaged 20.1°C at 17.9°C. At the same time, the average monthly air temperature in March was 1.4 ° C lower than normal and was only 0.6°C warm.

In the southern region, the temperature regime was slightly higher than the norm, according to which the long-term average was adopted, and during the vegetation periods of 2015-2017. The average daily air temperature exceeded the norm (17.9°C) by 1.5; 1.5 and 1.1°C, respectively.

It is determined that in hot, in addition to dry weather, the plant is able to lose by transpiration up to 0.5 kg of water per 1 m2 for 1 hour, which corresponds to a loss of about 350 watts of heat energy per 1 m2. This value is almost half of the total amount of energy absorbed by the plant itself. Due to such mechanisms, plants can strongly regulate their temperature. This ability is closely correlated with the relative humidity [17].

It is well known that the normal temperature of plants requires an optimal temperature in the range of 5-30°C. A larger excess of this indicator significantly weakens the physiological and metabolic processes in alfalfa.

It is generally accepted in science that the temperature should be summed not from zero on the scale of the thermometer, but from the limit from which the development of the plant begins, ie from zero to the effective temperature. For many plants, including alfalfa, the lower limit of effective temperature is close to 5ºC.

In order to determine the heat supply of alfalfa plants, we used the sum of effective temperatures above 5 ° C. They have ecological significance and characterize the provision of the studied varieties with heat.

It is established that the sum of effective air temperatures above + 5ºC was the highest during the vegetation period of alfalfa in 2018. This indicator reached the level of 2768ºC, which was 400ºC more than the norm (2368ºC). Slightly higher than the norm of heat supply was found during the growing seasons of 2015-2017, which indicates a significant warming in the southern region (Table 2).

The main criterion for determining the suitability and economic value of a crop to local soil and climatic conditions is its productivity. It depends on many factors, including the variety.

For the period of laying the experiment to determine the most adapted to arid conditions plant varieties in 2015 BC The State Register of Plant Varieties Suitable for Distribution in Ukraine included 27 varieties of alfalfa for sowing and 11 - variable. Over time, inIn 2019, their number increased to 34 and 12 varieties, respectively [20, 21]. The varieties Vavilovka 2, Veselka, Laska, Lyuba,

Nasoloda, Unitro, which we studied, are classified as variable, and the varieties Nadezhda and Regina are classified as alfalfa.

Plant productivity is determined by a set of indicators, in particular such as the yield of aboveground leaf biomass, dry matter, the yield of feed protein units per unit area, the accumulation of energy in the crop.

According to scientists from the Institute of Irrigated Agriculture NAAS, the yield is a consequence of a compromise between plant productivity and its resistance to adverse environmental conditions [22].

Table 2

The sum of effective air temperatures is above + 5ºC in the years of research

Months	Years				Medium-perennial
	2015	2016	2017	2018	
March	0	36	59	0	0
April	104	264	191	267	132
May	473	602	538	707	479
June	953	1109	1042	1229	938
July	1520	1701	1594	1812	1487
August	2115	2293	2188	2435	2014
September	2583	2677	2611	2768	2368
During the growing season	2583	2677	2611	2768	2368
Deviation from the norm ±	215	309	243	400	0

In the first year of the growing season, the yield of alfalfa hay was low, due to the biological characteristics of the studied plants, so the hay yield was the lowest compared to all subsequent years of use for fodder purposes.

It was established that in the first year of vegetation the highest yield of alfalfa leaf mass on hay was formed by plants of Nasoloda variety - 2.34 t/ha. Regina (2.32 t/ha) and Lyuba (2.31 t/ha) were less productive. The lowest yields were formed by plants of the standard variety Nadezhda (2.26 t/ha), accepted for control in the experiment (Table 3).

Table 3

Yield of hay of alfalfa varieties

Sort	Hay yield, t / ha					± to control	
	2015	2016	2017	2018	average	t / ha	%
Hope - standard (control)	2.26	3.42	2.80	2.83	2.83	0	0
Unitro	2.28	3.48	3.09	3.12	2.99	0.16	5.7
Beloved	2.31	3.55	3.23	3.20	3.07	0.24	8.6
Pleasure	2.34	3.66	3.34	3.14	3.12	0.29	10.2
Rainbow	2.25	3.59	3.32	3.21	3.09	0.26	9.3
Vavilovka 2	2.27	3.75	3.36	3.27	3.16	0.33	11.7
Affection	2.29	3.54	3.10	3.01	2.99	0.16	5.5
Regina	2.32	3.52	3.12	3.07	3.01	0.18	6.3
Average	2.29	3.56	3.17	3.11	3.03	-	-
NIR_{05}, t / ha	0.022 th most common	0.120	0.179 th most common	0.134 th most common	0.129	-	-

More favorable weather conditions in 2016 had a positive effect on the formation of the hay harvest. In addition, alfalfa plants of the second year of life (and use) provided higher productivity of varieties compared to the first and third and fourth years of life.

On average in 2015-2018, the largest hay harvest was provided by growing varieties Vavilovka 2 (increase of 0.33 t/ha or 11.7% to the standard variety Nadezhda, the yield of which was 2.83 t/ha). Also noteworthy are the varieties Nasoloda, Veselka and Lyuba (yield increase was 10.2, 9.3 and 8.6% higher than the control, respectively). Significantly higher against control plants is the productivity of alfalfa varieties Regina, Unitro, Laska, for the cultivation of which the increase in hay yield was 6.3, 5.7, 5.5% to control.

At the same time, it is generally accepted that green mass (or hay) should not be assessed as the main criterion of crop productivity. Its volume depends primarily on its moisture content. More

objectively, the level of productivity of a crop is determined by the yield of dry matter.

On average in the experiments, the highest yield of dry matter was formed by the variety Vavilovka 2 (2.69 t/ha), which is 0.28 t/ha higher than the standard variety Nadezhda. More dry matter was synthesized against the control and plants of the varieties Nasoloda, Veselka and Lyuba (increase in yield by 0.24, 0.22 and 0.20 t/ha compared to the control) (Table 4).

Table 4

Productivity of alfalfa plants depending on the variety (average for 2015-2018)

Sort	Collection of 1 hectare			
	hay, t	dry matter, t	KPO, vol	exchange energy, GJ
Hope - standard (control)	2.83	2.41	2.02	18.88
Unitro	2.99	2.54	2.14	19.94
Beloved	3.07	2.61	2.20	20.48
Pleasure	3.12	2.65	2.23	20.81
Rainbow	3.09	2.63	2.21	20.61
Vavilovka 2	3.16	2.69	2.26	21.08
Affection	2.99	2.54	2.14	19.94
Regina	3.01	2.56	2.15	20.08
Average	3.03	2.58	2.17	20.23

Dry matter also does not fully reflect the forage quality of plants. For a more objective characterization of the nutritional value of the formed crop, it is important to determine the collection of feed protein units (CPU). This indicator determines not only the total but also the protein nutrition of the harvest. Its value is due to the fact that it takes into account not only the provision of feed with crude protein, but also emphasizes its full value, ie the number and ratio of essential amino acids.

There is no consensus among scientists on the nutritional value of agricultural plants, because their content of feed units, digestible protein depends on many factors, including growing conditions, phases of plant development, varieties, etc.

It is generally accepted that in the first year of life for the formation of a slope for green fodder (or hay) the sum of effective temperatures (approximately) should be 1300°C. For the second and subsequent years of life, an average of 900°C is enough to form an alfalfa slope. At the same time, due to the lack of such a resource as moisture in today's conditions, such an additional resource as heat supply is not effectively used.

It is established that in the first year of life (and use) at 1ºC effective air temperatures above + 5ºC a leaf-stem mass is formed for harvesting 1.76 kg of hay on average by varieties. In the second, third, and fourth years of life, this indicator reaches the level of 3.96, 3.52, and 3.46 kg per 1°C of effective temperature (Table 5).

Table 5

Use of heat supply by plants of alfalfa on hay depending on the variety

Sort	Hay was formed, kg / 1ºC of effective air temperatures above + 5ºC					± to control	
	2015	2016	2017	2018	average	kg / 1ºC	%
Hope - standard (control)	1.74	3.80	3.11	3.14	2.95	0	0
Unitro	1.75	3.87	3.43	3.47	3.13	0.18	6.1
Beloved	1.78	3.94	3.59	3.56	3.22	0.27	9.1
Pleasure	1.80	4.07	3.71	3.49	3.27	0.32	10.8
Rainbow	1.73	3.99	3.69	3.57	3.25	0.30	10.0
Vavilovka 2	1.75	4.17	3.73	3.63	3.32	0.37	12.5
Affection	1.76	3.93	3.44	3.34	3.12	0.17	5.7
Regina	1.78	3.91	3.47	3.41	3.14	0.19	6.5
Average	1.76	3.96	3.52	3.46	3.18	-	-

On average for 2015-2018 (the first - fourth years of life and use of alfalfa for hay) harvested at 1ºC effective air temperatures above + 5ºC most hay variety Vavilovka 2 - 3.32 kg, which is 0.37 kg, or 12, 5% more than the control variety Nadezhda. In the varieties Nasoloda, Veselka and Lyuba, this figure

increased by 10.8, 10.0 and 9.1%, respectively, compared with the control (2.95 kg / 1ºC effective air temperatures above + 5ºC).

The above indicators indicate that the varieties Vavilovka 2, Nasoloda, Veselka and Lyuba are more adapted to the arid conditions of the southern steppe and therefore more productive compared to control plants. They also provide a larger collection per unit area of feed protein units and metabolic energy (see Table 4).

Alfalfa is characterized by high water consumption. Plants consume a significant amount of water during a long growing season, due to its increased growth and accumulation, with sufficient rainfall and reserves of productive (soil) moisture, large terrestrial biomass to each slope. At the same time, alfalfa is considered a drought-resistant plant due to its characteristic ability to tolerate short-term drought. However, prolonged drought has a negative impact on productivity.

It was found that during the harvest of alfalfa for hay, the reserves of productive moisture in the soil decreased compared to the initial (spring) period of plant growth. Thus, in early August 2015, a drought was observed under crops of the first year of life (the reserves of productive moisture of a meter layer of soil amounted to 16 mm). In 2016, under alfalfa crops of the second year of life, during the haymaking period, a meter layer of soil was satisfactorily moistened (88 mm). Regarding the soil moisture supply of alfalfa, in 2017 the meter layer was again covered by soil drought (11 mm). In 2018, moisture reserves in the meter layer were also unsatisfactory (10 mm).

It is calculated that in the first year of life (and use) per 1 mm of precipitation and productive moisture of 0-100 cm of soil layer is formed leaf-stem mass for harvesting 7.41 kg of hay on average by varieties. In the second, third, fourth years of life, this figure reaches the level of 18.64, 14.59, 13.99 kg per 1 mm of water (Table 6).

Table 6

Use of precipitation and productive moisture reserves of a meter layer of soil by sowing alfalfa on hay depending on the variety

Sort	Formed hay, kg / 1 mm of moisture 0-100 cm layer of soil and precipitation					± to control	
	2015	2016	2017	2018	average	kg / 1 mm	%
Hope - standard (control)	7.31	17.89	12.89	12.74	12.71	0	0
Unitro	7.38	18.20	14.22	14.05	13.46	0.75	5.9
Beloved	7.48	18.57	14.86	14.41	13.83	1.12	8.8
Pleasure	7.57	19.14	15.37	14.14	14.06	1.35	10.6
Rainbow	7.28	18.78	15.28	14.45	13.95	1.24	9.7
Vavilovka 2	7.35	19.61	15.46	14.72	14.29	1.58	12.4
Affection	7.41	18.51	14.27	13.55	13.44	0.72	5.7
Regina	7.51	18.41	14.36	13.82	13.53	0.82	6.4
Average	7.41	18.64	14.59	13.99	13.66	-	-

On average for 2015-2018 (the first – fourth years of life and use of alfalfa for hay) 1 mm of available moisture of precipitations and from soil most of hay of the Vavilovka 2 grade – 14,29 kg that on 1,58 kg, or 12,4% more than the control variety Nadezhda. In the varieties Nasoloda, Veselka and Lyuba, this figure increased by 10.6, 9.7 and 8.8%, respectively, compared with the control (12.71 kg / 1 mm of moisture).

The extraordinary value of alfalfa as the most productive and high-protein crop among perennial grasses to strengthen the fodder base is noted in the publication "Concept of fodder production in Ukraine until 2025", prepared by scientists from the Institute of Fodder and Agriculture of Podillya NAAS. In the steppe zone, it should be located on 60-70% of the total sown area of legumes [23].

First of all, it is proposed to introduce into production new domestic varieties of alfalfa sown and variable, adapted to the soil and climatic conditions of growing areas.

Conclusions. Productivity of alfalfa plants significantly depends on weather conditions of a year, a grade, life expectancy. Due to the lack of moisture, such an additional natural resource as heat supply is not used effectively.

On average for four years of life and use (2015-2018), the highest yield of hay under arid conditions on the non-irrigated lands of chernozems of southern Ukraine was provided by the alfalfa variety Vavilovka 2 (increase of 0.33 t/ha or 11.7% to the standard variety Hope accepted for control, the yield of which was 2.83 t/ha). Also worth noting are the varieties Nasoloda, Veselka and Lyuba (yield

increase of 10.2, 9.3 and 8.6%, respectively, compared to the control).

Varieties Vavilovka 2, Nasoloda, Veselka and Lyuba are more adapted to arid conditions of the southern Steppe and therefore more productive in comparison with control plants. The above varieties also provide a greater collection per unit area of feed protein units and metabolic energy.

Slightly higher against control plants is the productivity of alfalfa varieties Regina, Unitro, Laska, for the cultivation of which the increase in hay yield was 6.3; 5.7; 5.5% to control.

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Л. К. Антипова. **Формирование урожайности сортов люцерны на сено в Южных степях Украины**

Представлены результаты исследования формирования урожайности сортов люцерны на сено в неорошаемых агрофитоценозах в период глобального потепления на юге Украины. Установлено, что некоторые районированные в Украине сорта более адаптированы к засушливым условиям Южной степи и поэтому более урожайны (5,5-11,7% на сенокос) по сравнению с контрольными растениями (сорт Надежда – урожайность сена в среднем за четыре года жизни люцерны составила 2,84 т/га).

***Ключевые слова**: люцерна, сорт, погодные условия, сено, урожайность.*

Л. К. Антипова. **Формування урожайності сортів люцерни на сіно в степах Південної України**

Представлено результати дослідження формування продуктивності сортів люцерни на сіно в неполивних агрофітоценозах під час глобального потепління на півдні України. Встановлено, що деякі районовані в Україні сорти більш пристосовані до посушливих умов Південного степу і отже – більш врожайні (5,5-11,7% на врожай сіна) порівняно з контрольними рослинами (сорт Надія – урожайність сіна у середньому за чотири роки життя люцерни склала 2,84 т/га).

***Ключові слова**: люцерна, сорт, погодні умови, сіно, продуктивність.*