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NATURAL FODDER LANDS OF UKRAINIAN STEPPE ZONE: CURRENT STATE AND MAIN WAYS OF PRODUCTIVITY RESTORATION

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Abstract

The results of scientific research on the current state of agro-landscapes of the Southern Steppe and the main agro-technological measures to reduce the manifestation of the mentioned negative phenomena are presented. The latter is achieved by creating high-yielding mono-species agrophytocenoses of perennial legumes and leguminous grass mixtures resistant to regional climate changes, which have been observed in recent years in the southern region. Systematic expansion of lands under cereals and industrial crops which are in demand on the international market, has led to the unstable state of agricultural lands in the steppe zone of Ukraine, their area at the beginning of the XXI century being one of the highest in the world and amounting to 90.2% in Kherson region. It was found that the plough land on the territory significantly exceeds the ecologically permissible limits, as a result of which the physical and chemical degradation of soils began to increase intensively, which leads to a significant reduction in the formation of high crop yields. The consequences of these changes were highly unfavorable for the development of agriculture in all regions of the Southern Steppe of Ukraine, which is due both to plowing up extensively the agricultural landscapes and changes in the sown area structure. The main way to reduce physical and chemical degradation of areas under crops under the natural moistening conditions is the creation of high-yielding mono-species agrophytocenoses of perennial legumes and poly-species leguminous - grass mixtures resistant to extreme weather conditions of southern steppes.

Key words: evaporation, precipitation, lack of moisture supply, land degradation, perennial grasses, grass mixtures, growth regulator, peat

INTRODUCTION

The creation of a reliable fodder base in the country allows the revival of the livestock industry. It is well known that the cheapest and most effective source of fodder is meadows and pastures. The area of meadows in the world is 313 billion hectares, or twice the area of arable land. In Ukraine, on the other hand, arable land area is almost five times larger than meadows. The area of plowed land in Ukraine makes about 82% of agricultural land. The most valuable productive lands of the Forest-Steppe and Steppe are plowed, in particular, in the Kherson region they amount to 90.2%, in Mykolaiv – to 83.6% [18]. This leads to the annual degradation of agricultural land and the loss of about 600 million tons of humus. For comparison: plowed lands in the United States make 16.9%; in Australia – 16.4%; in Great Britain – 25.8%; in Belarus – 27.9%; in Moldova – 53.7%; in Poland – 35.7%; in Germany – 34.0%; in France – 33.5%; in the Netherlands – 31.0% [17].

Effective development of the livestock industry of the Ukrainian Southern Steppe agro-industrial complex is possible only on finding a comprehensive solution to the problem of introducing scientifically sound systems of fodder production as well as agriculture in general. The system of fodder production as a set of organizational and economic, agronomic and zootechnical measures aimed at maximizing the production of high quality fodder at the lowest labor expenditures and means of production per unit of fodder, is extremely difficult in the southern part of the steppe zone. The latter is related to the main direction of agricultural development in Ukraine, which underwent significant changes during 1991–2021. Irrational use of land resources in the southern part of the Steppe zone is primarily due to the significant changes in the structure of sown areas which has developed over the last 30 years in Ukraine (Table 1).

Table 1. Structure of sown lands in Ukraine in 2020 compared to 1990

Performances	1990		2020*	
	thous. ha	%	thous. ha	%
Sown area including:	32,218.0	100.00	27,973.0	100.00
1. Cereals and leguminous plants	14,583.0	45.26	15,364.7	54.92
including winter and spring wheat	5,480.0	17.01	6,571.3	23.49
Corn	1,200.0	3.72	5,451.3	19.49
winter and spring barley	3,003.0	9.32	2,384.9	8.52
other cereals and leguminous plants	4,900.0	15.21	957.2	3.42
2. Industrial crops	3,751.0	11.65	9,127.6	32.63
including sunflower	1,636.0	5.08	6,383.3	22.82
sugar beetroot	1,607.0	4.99	218.9	0.78
Soybean	93.0	0.29	1,340.5	4.79
winter and spring oilseed rape	90.0	0.28	1,115.2	3.99
other industrial crops	325.0	1.01	69.7	0.25
3. Potato, vegetables, melon and gourd	1,885.0	5.85	1,842.4	6.59
4. Forage crops	11,999.0	37.24	1,638.5	5.86

***** *Note: Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and parts of the lands in the area of the joint forces operation*
Source: the State Statistics Service of Ukraine [25].

Compared to 1990, the sown area of forage crops has significantly decreased. If the total area of forage crops in 1990 on the farms of all categories was 11,999.0 thousand hectares, in 2020 their sown area decreased to 1,638.5 thousand hectares, or by 10,360.5 thousand hectares, i.e. by 86.3%. Due to the reduction of forage crop sown areas, the main economic activity of agricultural enterprises and farms in recent years has been aimed at the cultivation of winter wheat, corn, sunflower and winter oilseed rape, which are in demand on the world market. As a result, the supply of fodder to farm animals, especially small and private farms, has become extremely low.

MATERIALS AND METHODS

In writing the article, data from the State Statistics Service of Ukraine, information from the agrometeorological station in Kherson and the results of the authors' own research were used. Empirical studies of the process of increasing the major crop yields were conducted using the methods of comparative, systematic and graphical analysis.

Field experiments on arable land alkalization were carried out in the KOPANI State Enterprise of the National Academy of Agrarian Sciences, Ukraine, in 2010-2019. The soil of the experimental plots was dark-chestnut, the topsoil containing humus (2.02-2.34% according to Tyurin), nitrate nitrogen ($N–NO_3$ – 8.00-12.30 mg kg^{-1}); mobile phosphorus (24.2-36.3% according to Machigin) and exchangeable potassium (330.00-413.00 mg kg^{-1} of soil).

The arable lands alkalinization was performed with cereals and leguminous perennial grasses as their biological features are best adapted to the natural and climatic conditions of the Southern Steppe. For a short period (not more than 2-3 years) the use of single-species crops of cereals and leguminous perennial grasses in grass mixtures included *Lolium multiflorum* Lam., Yaroslav variety and *Onobrychis arenaria* Kit., Ingulsky variety. *Festuca orientalis* (Hack.) V. Krecz., Domenica variety and *Medicago varia* T. Martyn, Veselka variety were used for medium-term restoration of soil fertility (3-4 years).

For long-term restoration of dark-chestnut soil fertility, *Medicago varia* T. Martyn), Veselka variety and *Bromopsis inermis* (Loyss.) Holub), Tavria variety were used. Sowing of cereals and leguminous perennial grasses in single-species crops and binary grass mixtures was carried out in early spring for three years (2016-2019). The sowing rate for short-term fertility restoration of degraded dark-chestnut arable lands, its economic suitability being 100%, in mono-species crops was: *Lolium multiflorum* Lam. – 24.0 kg ha^{-1}, *Festuca orientalis* – 24.0 kg ha^{-1}; *Onobrýchis arenária* – 80.0 kg ha^{-1}; in the composition of grass mixtures they were 12.0, 12.0 and 60.0 kg ha^{-1}, respectively.

In case of the long-term land fertility restoration, the sowing rate of *Medicago varia* seeds in single-species crops was 24.0 kg ha^{-1} and *Bromopsis inermis* – 28.0 kg ha^{-1}. As a part of binary grass mixes the rate of sowing made: *Medicago varia* + *Bromopsis inermis* – 12.0 + 14.0 kg ha^{-1}. The area of the sown area was 60 m^2, the discount area was 20 m^2. Yield recording was performed by cutting.

Dry matter content, grass stand density, change of species botanical composition, yield of fodder units, gross and metabolic energy were determined according to generally accepted methods [4]. Evaporation rate (Eo), moisture supply deficit (ΔEo) according to the years of research were determined by N.N. Ivanov [8]. Statistical analysis of the perennial grasses yield was performed by the method of variance analysis [27].

RESULTS AND DISCUSSIONS

The main forage crops are perennial grasses, which occupy about 50% of the total forage crops area. The fodder base is formed by those fodder crops that are characterized by the lowest cost of seeds, fuel, machinery and wages expenses which is of great importance in times of crisis but significantly worsens the fodder base [16]. One of the main reserves for increasing fodder production for the existing livestock industry is to increase the productivity of natural fodder lands, their total area in Ukraine amounting to 6,391.6 thousand hectares. However, the productivity of 1 ha of grassland is currently very low and does not exceed 1.0-1.2 t ha^{-1}, due to which they receive only 10-11% of the gross fodder harvest.

The main factor contributing to the high productivity of natural forage lands is a scientifically sound ratio of the arable land (arable land + perennial plantations) to the total area of agricultural land. In the US, this figure is 20.3%; Canada – 4.6%; the Netherlands – 24.3%; Germany – 32.0%; France – 34.7%, i.e. the structure of land use is optimized because up to 40.0-50.0% of the total land is occupied by nature-conservation areas, i.e. meadows and forests. The main factor that ensures the sustainable development of agro-ecological systems and the biosphere as a whole in these countries is the optimal ratio of arable land to the total agricultural area.

According to V.V. Dokuchaev [5], with intensive use of arable land, there must be an optimized ratio between the constituent parts of agricultural land. According to those time studies, the ratio of the perennial grasses lands to the total arable land, should be 20-25%, and the area of forest belts – 2.5-3.0%. Later scientific works by the Ukrzemproekt Land Management Institute gave a different ratio of agricultural land in the steppe zone: arable land – 55-60%, pastures and hayfields – 22-23%, perennial plantations and forest belts – 7.0-8.0%, recreational areas and water bodies – up to 6.0%. Depending on the territory distribution and the quality of the natural-climatic steppe zone soils, the above ratios may change slightly. On average, the optimal forest cover in Ukraine was recognized in the range of 19.0–20.0%, while in the Steppe zone it should reach 9.0%, Forest-Steppe – 18.0% and in Polissia – 32.0%.

Natural forage lands in the Steppe zone in 1980 occupied an area of 2,472.8 thousand hectares, their share in the total area of lands of all classes was 38.7%, in the natural-climatic zone of the Forest-Steppe – 1,674.0 and 26.2 and in zone of Polissia – 2,244.8 thousand hectares or 35.1%. At the same time, the total area of plain and gently sloping areas in the Steppe zone reaches 774.5 thousand hectares, steppe slopes – 960.3; non-saline

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soils – 59.8; upland – 39.2; lowland – 129.5; floodplain of small rivers and gullies – 442.7; floodplain of large and medium rivers – 55.9; mountain – 9.5 and lowland swamp – 1.4 thousand hectares [4] (Table 2).

Table 2. Distribution of natural forage lands by classes and their area in various zones of Ukraine, thousand hectares

Zone	Plain and sloping	Steppe	Non-saline	Upland	Lowland	Small rivers floodplain	Large rivers floodplain	Mountain	Lowland swamp	Total
Steppe	774.5	960.3	59.8	39.2	129.5	442.7	55.9	9.5	1.4	2,472.8
Forest-steppe	25.5	438.8	0.6	91.9	196.1	512.6	248.6	22.7	137.2	1,674.0
Polissia	3.3	13.4	–	132.1	875.5	333.4	292.1	240.3	354.7	2,244.8
Total	803.3	1,412.5	60.4	263.2	1,201.1	1,288.7	596.6	272.5	493.3	6,391.6

Source: Resolution of the Government of Ukraine of March 21, 1980 "On measures to increase the productivity of natural forage lands in the collective and state farms of the Ukrainian SSR in 1980–1985"[19].

The instability of natural moisture in the steppe zone, especially in moderately dry (75%) and dry (95%) years, negatively affects the changes in species botanical composition of existing grasslands and the productivity of the most common species of cereals and leguminous perennials. Having a strong root system, xerophytes make good use of soil moisture and due to pubescence, wax plaque and pre-folding of leaves in droughts, they easily restore turgor with even a small amount of precipitation.

Among xerophytes are succulents which are characterized by moisture accumulation in succulent leaves and stems (cacti, agaves) and which dominate in deserts and semi-deserts and sclerophytes which are characterized by narrow leaves easily twisted in drought. Due to this, the evaporation from leaves is significantly reduced.

Sclerophytes in the natural-climatic zone of the Steppe include: *Festuca rupicola* Heuft., or *Festuca sulcata* Hack.; *Stipa capillata* L.; *Stipa lessingiana* Trin. et Rupr.; *Stipa borysthenica* Klok., as well as *Artemisia vulgaris* L.; *Artemisia austriaca* Jacg.; *Artemisia arenaria* DC. and others.

In relation to moisture in the arid conditions of the steppe zone southern part, special forms of plants germinate here, namely, ephemerals and ephemeroids. The biological feature of the most common ephemeral annual plant *Anisantha tectorum* Nevski in the Southern Steppe subzone and *Astragalus dasyanthus* Pall., *Astragalus dasyanthus* Pall., *Astragalus austriacus* Jacg. and other plants is thin delicate leaves and an accelerated plant growth and development.

Annual and perennial ephemeral plants in the steppe zone of Ukraine germinate intensively and form seed crops in the period of short and wet spring, while the onset of drought stops their growth and development until the onset of favorable moisture and temperature conditions. Perennial ephemeroids which are common in the natural climatic part of the steppe zone, include: *Poa bulbosa* L., *Poa stepposa* Kryl., *Poa compressa* L., and such annuals as *Poa annua* L. and the *Stellaria media* L.

On dry natural forage lands, the total area of which in the steppe zone reached 39.2 thousand hectares, *Onobrychis arenaria* DC., *Melilotus officinalis* Hall., *Elitrigia elongate* Nevski., *Agropiron desertorum* Schult., *Psathyrostachys juncea* (Fisch.) Nevski are growing. At the same time, transitional (intermediate) types from xerophytes to mesophytes are found on these forage lands: *Agropiron pectinatum* Beauv., *Agropiron lavrenkoanum* Procud., *Medicago falkata* L., *Galium verum* L. and a number of thin-legged species that belong to ephemeroids and grow in desert areas only in spring. Due to the supply of nutrients in the tubers, they form thin, tender leaves and withstand summer drought.

Along with this, a number of distinctive features are observed among mesophytes in terms of soil moisture requirement. On lowland natural forage lands, which covered an area of 129.5 thousand hectares in the steppe zone of Ukraine, and floodplains of small rivers and gullies – 442.7 thousand hectares, in natural meadow agrophytocenoses *Trifolium repens* L. and *Trifolium hybridum* L. predominate among leguminous perennial grasses. Of the perennial grasses, *Festuca pratensis* Huds., *Poa palustris* L., *Alopecurus pratensis* L., *Phalaroides arundinacea* Rausch., and *Agrostis maeotica* Klok. dominate on the indicated forage lands.

Due to the significant increase in the moisture supply deficit, perennial grasses are mostly represented by unproductive ephemeral and ephemeroid species on the natural forage lands of the southern part of the Steppe zone: *Poa bulbosa* L., *Poa angustifolia* L., *Calamagrostis epigeios* (L.) Roth., *Cynodon dactylon* (L.) Pers., *Elytrigia repens* (L.) Nevski.

Of the legume species, monotype phytocenoses are dominant: *Lathyrus tuberosus* L., *Vicia cracca* L., *Medicago falcata* L., *Lotus ucrainicus* Klok. However, in conditions of natural moistening (without irrigation) in late May – early June, most cereal ephemeral and ephemeral species of grass stop growing and developing and die completely, thus they do not have a significant impact on the existing livestock industry feed supply, especially in average dry (75%) and dry (95%) years.

The most common annual ephemeral cereal grasses are: *Anisanta tectorum* Nevski, *Bromus mollis* L., *Bromus secalinus* L., *Vulpia ciliata* Dumort, *Aegilops cylindrica* Host., *Hordeum murinum* L., *Eremopyrum triticeum* (Gaerth) Nevski, *Setaria glauca* L., *Setaria viridis* L.

Due to the above, the available phytocenoses of natural forage lands revealed a very limited amount of high-yielding meadow vegetation, the range of annual and perennial grasses includes only 35 species, including 23 species of annual, 5 biennial and only 7 perennial grasses.

In most areas of the southern part of the steppe zone, especially on large-scale sunflower fields a mass appearance of atypical for the region weeds was found in recent years: *Lactuca tatarica* L., *Anisantha tectorum* Nevski, *Cyclachaena xantifolia* L., *Ambrosia artemisifolia* L., etc.

The spread of *Ambrosia artemisifolia* L. in the southern regions of Ukraine is associated with the high competitiveness of this species, due to which it began to occupy a dominant position in the agrophytocenoses.

However, due to the lack of sufficient seeds of alfalfa (*Medicago sativa L.*) and drought-resistant species of perennial grasses, primarily *Bromopsis inermis* (Leyss.) Holub, *Bromopsis erecta* (Huds.) Holub, *Dactylis glomerata* L., *Elytrigia intermedia* (Host Nevski), etc re-alkalinization of forage lands of different classes in the steppe zone was not carried out in recent years as a result of which a shortage of green and roughage yields annually amounts to 9.5-12.0 million tons of fodder units and to 1.8-2.0 million tons of digestible protein.

Along with the significant impact of extremely high plowing of plains and sloping natural forage lands, as well as agricultural lands of the southern steppe zone as a whole, in recent years there has been a significant impact of regional climate changes on the formation of their productivity, causing the intensive changes in the structures of existing agrolandscapes.

The increase in the average monthly air temperature during the growing season of 2018-2020 by 1.7-2.8 °C, compared with the average long-term figures for 65 years (1945-2010), significantly affected the changes in water regime of forage crops grown under non-irrigated agriculture conditions in the subzone of the Southern Steppe.

In general, during the growing season (April-September) in the dry year of 2020 (95%) the rainfall only amounted to 163.6 mm, the evaporation reached 947.5 mm and the deficit of moisture supply (ΔEo) – 783.9 mm and, compared to the average long-term figures for 65 years (1945-2010), was higher by 290.1 mm, or 58.7% (Figure 1).

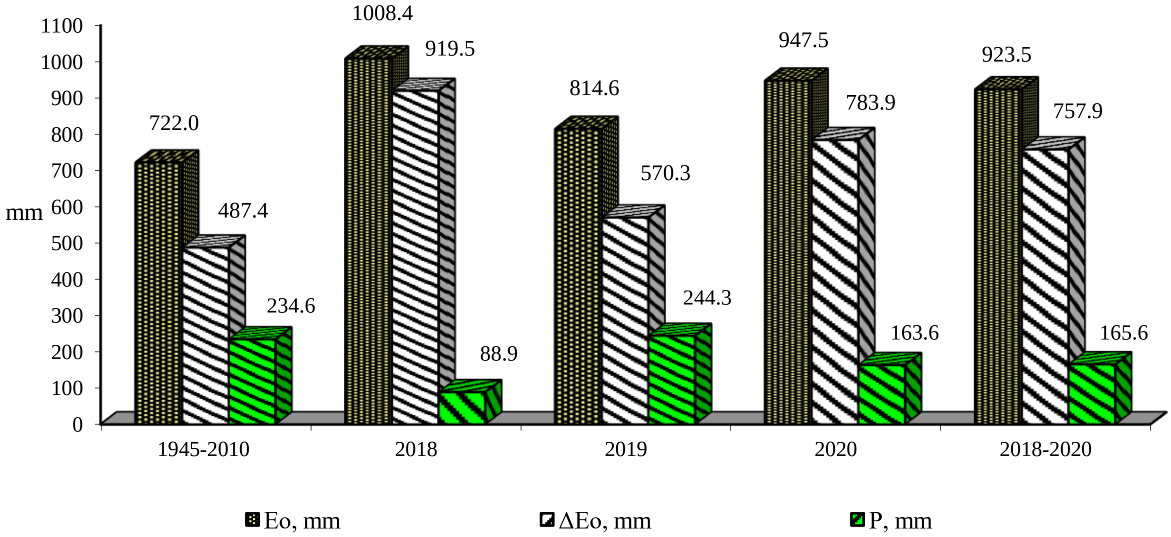

Fig. 1. Evaporation (Eo), deficit of moisture supply (ΔEo) and the amount of precipitation (P) during the growing season in the Southern Steppe of Ukraine
Source: The Meteorological Station of Kherson [26].

The degree of cultivated forage crops moisture supply during their growing season, established by the moisture coefficient, shows that in April it was 0.03; in May – 0.29; in June – 0.13; in July – 0.29; in August – 0.12 and in September - 0.15 (Figure 2).

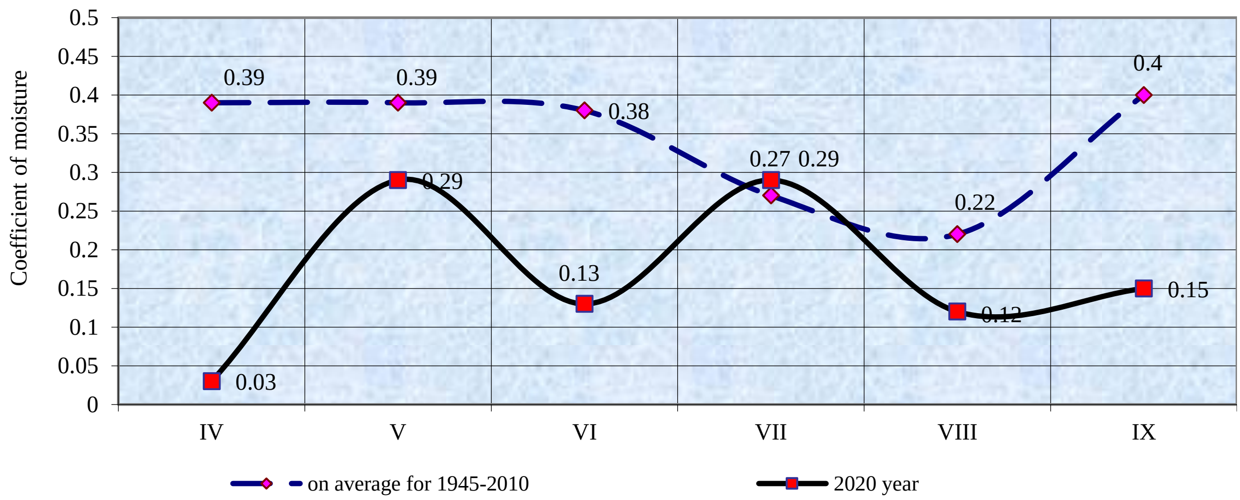

Fig. 2. Coefficient of moisture supply during the forage crops growing season in the dry year of 2020 (95%)
Source: The Meteorological Station of Kherson [26].

However, the disadvantage of energy-saving technology aimed at improving natural forage lands was the uneven germination of sown grasses and those that are already growing because of the plants mutual shading [15].

Due to the fact that the potential of natural hayfields and pastures in Ukraine is used very poorly, cultivated pastures can play a special role as a factor in significant savings of material, technical and energy resources [21, 23, 24, 29]. In addition, cultivated pastures are also of great economic and agronomic importance: their creation on the slopes stops water and wind erosion and helps to restore soil structure and, consequently, increase its fertility [2, 3, 11, 22].

In Western European countries cultivated pastures occupy 70-85% of all land under perennial grasses. In Denmark, 80% of fodder is obtained from such pastures. In England and the Netherlands the proportion of pasture feed in the annual cattle diet makes 35-50%

[6]. Much attention is paid to the creation of cultivated pastures in Latin America and Africa [9, 7, 10], which helps to solve not only forage production problems but also the problems of soil conservation [1].

However, when creating a cultivated pasture, it should be treated it with no less attention than wheat or any other field, it should be provided with necessary fertilizers and equipment, with the optimal set of perennial grass seeds for each zone [12, 13, 14, 30]. The solution to this problem can be achieved only owing to the state support of long-term cultivated pastures for beef cattle by funding targeted local programs specifically aimed at improving pastures for grazing and private farms in particular [28, 20].

In our research on non-saline natural forage land surface improvement, the yield of absolutely dry matter of *Medicago* variety Unitro in the first year averaged 3.30-3.32 t ha^{-1} in the three years of research with natural moistening (without irrigation), while that of *Elytrigia intermedia* (Host.) Nevski – 3.24-3.44 and binary grass mixture *Elytrigia* + *Medicago* – 3.33-3.50 t ha^{-1} (Table 3).

Table 3. Yields of absolutely dry matter of perennial grasses with surface improvement of non-saline natural forage lands in the Southern Steppe of Ukraine (*on average for 3 years of research*)

Agrophytocenosis composition (A)	Year of application					
	first		second		third	
	Yield, t ha^{-1}	Energy consumption, MJ t^{-1}	Yield, t ha^{-1}	Energy consumption, MJ t^{-1}	Yield, t ha^{-1}	Energy consumption, MJ t^{-1}
Top-dressing with Plantafol 30.10.10 (B)						
No Plantafol 30.10.10 application (B_1)						
Elytrigia intermedia (Host.) Nevski. (E)	3.24	6,427.5	2.70	7,713.0	1.86	10,360.7
Medicago (M)	3.30	2,841.2	2.49	3,765.5	1.67	4,883.3
E+M	3.33	5,473.0	2.88	6,328.1	1.81	9,642.8
Onobrychis arenaria (O)	3.39	2,990.8	2.73	3,713.9	1.65	5,205.1
E+O	3.64	5,111.8	2.78	6,693.2	1.78	9,303.5
E+M+O	3.70	4,996.2	2.79	6,625.8	1.82	9,243.0
With Plantafol 30.10.10 application (B_2)						
Elytrigia intermedia (Host.) Nevski. (E)	3.44	6,253.2	2.71	7,937.6	1.91	10,755.5
Medicago (M)	3.32	3,030.4	2.63	3,825.5	1.70	5,380.2
E+M	3.50	5,403.1	2.88	6,566.3	1.88	9,798.4
Onobrychis arenaria (O)	3.67	2,949.6	2.73	3,965.2	1.73	5,494.9
E+O	3.77	5,117.5	2.91	6,629.9	1.88	9,695.0
E+M+O	3.81	5,031.8	2.87	6,679.8	1.89	9,585.5

Assessment of the partial differences significance:

SSD_{05}, t ha^{-1} – (A)	0.40	0.09	0.08
SSD_{05}, t ha^{-1} – (B)	0.30	0.09	0.05

Source: own research.

Therefore, one of the most effective ways to increase the productivity of natural forage lands, which is currently underutilized by small-scale farms in the Southern Steppe, is to expand the sown areas of the most drought-resistant cereals and leguminous perennials and, above all, alfalfa and sainfoin.

Energy consumption of 1 ton of absolutely dry matter of binary wheatgrass medium + alfalfa grass mixture regardless of the use of Plantafol 30.10.10 growth regulator, the first year of use, for surface improvement of non-saline natural forage lands, was 5,403.1-5,473.0 MJ, the second – 6,328.1-6,566.3 and the third – 9,642.8-9,798.4 MJ, respectively.

On the thinned natural forage lands with the predominance of low-yielding plants of the herbaceous group, a radical improvement of natural forage lands is carried out. In general, radical improvement is the main method of cultivating natural forage lands of all classes, as its implementation contributes to the creation of optimized water, nutrient and air regimes of the soil.

In carrying out a radical improvement of the natural forage lands of the Lower Dnieper Sands (Oleshky Arena), we used the method of soil reclamation consisting in layer-by-layer application of peat as an organic fertilizer. The sands of the experimental field were characterized by extremely low fertility (humus content – 0.08%, mobile phosphorus P_2O_5 – 0.95-1.0; exchangeable potassium K_2O – 2.5-3.0 mg 100 g^{-1} of soil) and the predominance of coarse and fine sand particles in the granulometric composition (39.56–51.71%).

Layered application of peat solved one of the main problems, namely, the increase of the sand fertility. For this purpose, local organic peat fertilizer was applied in two layers up to 500 t ha^{-1}. For this, a tracklaying tractor rammed a rut for wheeled transport, the previously planned field was rammed with a tracked tractor to spread peat (RUN–15B) up to 300 t ha^{-1}, turned it under with a plow to the depth of the topsoil. The second fertile layer was created by applying peat (up to 200 t ha^{-1}) and mineral fertilizers ($N_{60}P_{60}K_{100}$) by sifting and mixing them with disc harrows BDNT-2.2 in two tracks in the upper layer to a depth of 0-10 cm. Immediately after the application of mineral fertilizers, the soil was rolled by ring rollers, which contributed to obtaining uniform seedlings of cereals and leguminous perennials.

The proposed method solves several pressing problems of agricultural production: development of low-yielding lands for irrigated cultivated hayfields, increasing their fertility, protection of sandy lands from wind erosion, preservation of the environment. Its application on irrigated lands allowed to obtain 50.0–60.0 t ha^{-1} of green mass of alfalfa-cereal grass mixtures for several years.

Under the irrigation, the most productive were grass mixtures of blue hybrid alfalfa, foxglove, grasshopper and perennial fenugreek. The yield of absolutely dry matter of these types of grasses and their grass mixtures, on average for five years of research, was 12.9-14.0 t ha^{-1}, respectively, feed units – 8.9-9.4 t ha^{-1}; digestible protein – 1.9-2.1 t ha^{-1} and metabolic energy – 135.1-146.3 GJ ha^{-1}. The yield of absolutely dry matter from single-species crops of foxglove was 12.92 t/ha, respectively, fodder units – 8.66; digestible protein – 1.51 t ha^{-1} and metabolic energy – 135.1 GJ ha^{-1} (Table 4).

Table 4. Productivity of single-species crops of *Bromus inermis* and *Medicago-Bromus* grass mixtures when grown on reclaimed sands under irrigation in the Southern Steppe of Ukraine *(average over five years)*

Grasses and grass mixtures	Yield from 1 ha			
	Absolutely dry matter, tons	Fodder units, tons	Digestible protein, tons	Metabolizable energy, GJ
Bromus inermis (Bi)	12.92	8.66	1.51	135.1
(Medicago Khersons'ka 1)+Bi+LpD+D+Lp	12.89	8.76	1.99	135.7
(Medicago Khersons'ka 7)+Bi+LpD+D+Lp	13.52	9.19	1.99	142.8
Medicago (B-3504)+Bi+LpD+D+Lp	13.51	9.05	1.90	140.9
Medicago (B-3521)+Bi+LpD+D+Lp	13.30	8.91	1.94	140.4
Medicago (B-3521)+Bi+LpD+D+Lp	13.06	8.88	1.98	137.1
Medicago (B-480)+Bi+LpD+D+Lp	13.61	9.39	2.03	143.7
Medicago (B-426)+Bi+LpD+D+Lp	13.97	9.36	2.06	146.3
LSD_{05}, t ha^{-1} (GJ)	0.30	0.22	0.14	3.25

Note: Bi – *Bromis inermis*; LpD - *Lolium pratense* (Huds.) Darbysh.; D – *Dactylis glomerata*; Lp - *Lolium perenne*.
Source: own research.

The most productive were grass mixtures with different varieties of *Medicago, Bromis inermis*; *Lolium pratense* (Huds.) Darbysh.; *Dactylis glomerata* and *Lolium perenne*. The yield of absolutely dry matter of these types of grasses and their grass mixtures from 1 ha on average for 5 years was 12.89–13.97 t ha^{-1}; fodder units – 8.76–9.39; digestible protein – 1.99–2.06 t ha^{-1} and metabolic energy – 135.7–146.3 GJ ha^{-1}.

Inclusion of different varieties and cultivars of alfalfa and cereal perennial grasses in the composition of grass mixtures contributed to a significant increase in the essential nutrient content: fodder units – by 0.67–0.70 t ha^{-1} (8.1–8.4%), digestible protein – by 0.55–0.57

t ha^{-1} (36.4–44.5%) and exchange energy – by 7.4–10.6 GJ ha^{-1} (6.0–7.8%). The content of basic organic nutrients (crude protein, crude fiber and crude fat) corresponded to the zootechnical cattle feeding standards and made: crude protein – 19.28–21.66%; crude fiber – 26.77–29.80; crude fat – 2.99–3.36% in absolutely dry matter. The content of mineral elements in the crude ash was within the zootechnical cattle feeding standards and made: nitrogen – 3.12–3.46%, phosphorus - 0.60–0.65 and potassium – 2.64–3.13% in absolutely dry matter.

CONCLUSIONS

Under natural moistening, the formation of absolutely dry matter of single-species alfalfa and sainfoin, as well as wheatgrass and wheatgrass-alfalfa and wheatgrass-sainfoin grass mixtures with surface improvement of non-saline soils of the Southern Steppe depended significantly on rainfalls and changes in the species botanical composition, species of grasses and grass mixtures during the years of their use.

Growing single-species crops of drought-resistant legumes of perennial grasses and wheatgrass during the first year of use in non-irrigated agriculture contributed to the yield of absolutely dry alfalfa – 3.30–3.32 t ha^{-1}, sainfoin – 3.39–3,67 and wheatgrass – 3.24–3.44 t ha^{-1}. During the second year of use, the yield of absolutely dry matter of wheatgrass was 2.70–2.71 t ha^{-1}, alfalfa – 2.49–2.63 and sainfoin – 2.73 t ha^{-1}, respectively, the third year of use – 1.86–1.91 t ha^{-1}, 1.67–1.70 and 1.65–1.73 t ha^{-1}, respectively.

Under irrigation, the most productive were grass mixtures of alfalfa (*Medicago x varia* Martyn), *Bromus inermis*, *Dactylis glomerata* L. and *Lolium perenne*. The yield of absolutely dry matter of these grasses and their mixtures, on average for five years was 12.9–14.0 t ha^{-1}, fodder units – 8.9–9.4 t ha^{-1}; digestible protein – 1.9–2.1 t ha^{-1} and metabolic energy – 135.1–146.3 GJ ha^{-1}.

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