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PERSPECTIVES OF HAY-MAKING PRODUCTION ON SLOPES WITH SOUTH AND NORTH ORIENTATION ON EXAMPLE OF CHERNOZEM PODZOLIZED IN UKRAINE

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Abstract

The aim of this work was to compare the results of biogeocenotic perspectives estimation for vegetation cover on slopes of different orientations (north and south) on an example of chernozem podzolized, situated in Forest Steppe of Ukraine. Geocenotic characteristics included nitrogen, phosphorus, and potassium content in the soil, so as soil organic matter (humus) and the reaction of the soil solution (pH)– determined for the basic genetic horizons of soil profiles. Biocenotic characteristics included analysis of the plants species composition and yield of grasses on each slope, according to the moisture regime differences and changes in humus content and reaction of the soil solution. The article presents the botanical composition of natural herbage on both slopes of different exposure and presents the humus content and soil pH data by comparing the data of 1987 and 2017 years. The percentage of prevailing herbs families of hillside area and the number of hay-making production are also presented.

Key words*: *biogeocenosis, slope lands, orientation, adaptation, botanical composition

INTRODUCTION

Meadow grasslands, especially on hillsides, have multicomponent and important soil and plant (biogeocenotic) structure. They are the major energy storage and organic matter producers. Creating a thick vegetation cover, they reliably protect the soil from water and wind erosion and serve as an important source of high-quality cheap forage at the same time [4, 6]. The most favorable conditions for plant growth and development are provided by black soils (in Ukraine - *chernozems*) due to the combination of their optimal physical, chemical and agrophysical properties. The reproduction of highly productive and erosion-resistant natural grasslands on hillsides has an economic and environmental profit. Biogeocenoses heterogeneity of plants is such an important feature of vegetation agglomeration that plays an important role in the plant adaptation processes to seasonal and varied changes in ecological conditions and require necessary phytogenesis resources [2].

The assessment of hillside exposure (slope orientation) during the comparison of their biogeocenotic functions is important because it allows us to take into account the difference between their microclimatic indices and to find the difference in the quantitative and qualitative composition of the expected biomass.

The uneven distribution of rainfall and varied utilization of water due to the different intensity of transpiration and evaporation processes on the slopes of different exposure are important for the qualitative and quantitative composition of plants. The maximal intensity of these processes is on the slopes of the southern exposure that receive the largest amount of solar energy [13].

In Ukraine, the crucial moisture deficiency has an impact on vegetation mostly in spring and early summer, when short rainfalls occur. Vegetation on the eastern, southern and western slopes suffers the most, while at foothills additional humidity can be observed [14]. Therefore, the task of assessing biogeocenotic features in order to optimize the functioning of natural forage lands on the hillsides and to preserve their species diversity due to changes in soil fertility over time is a necessary and relevant objective.

MATERIALS AND METHODS

Investigation of biogeocenotic features of hillside lands due to soil fertility parameters and characteristics of botanical composition along with grass yields were conducted in the conditions of *chernozem podzolized on loess*, located in the middle part of slopes with different exposure (north and south) within "Balanchivska" ravine, near village Momotovo in Kharkiv region.
Additionally, comparisons of similarly obtained results were made for both slopes with different exposures [8]. Geographic coordinates of the hillsides location for the north exposure - N = 36.44890, E = 50.06030; for the south - N = 36.44890, E = 50.06100. Mapping of the study area, hillside shapes and their locations with geographic coordinates are presented below (Fig.1). A comparison of results for the study area obtained by similar methods for soil parameters (the total humus content and the reaction of the soil solution) included relation to the metrics obtained 30 years ago. In addition, laboratory research methods in present days also included the horizon-wise determination of the ammonium nitrogen content (NH_4), flexile phosphorus (P_2O_5) and potassium (K_2O) content [5]. The observation, accounting, and production of yield data for terrestrial plant biomass were performed according to generally accepted methods. Biomass analysis of mowed grass was carried out with a working tool – compact mower at a cutting height of 5-6 cm. Also, we determined the yield of green and air-dry biomass, botanical analysis of herbage on dried samples (selected for drying to determine hay yield over the past several years).

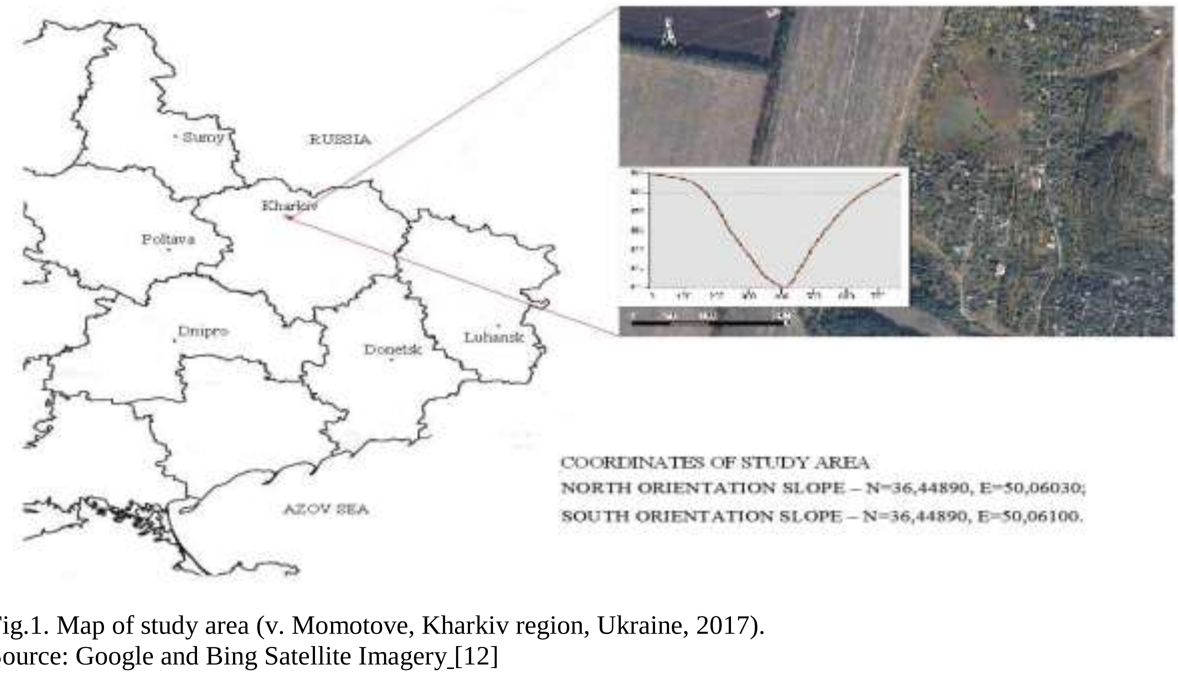

Fig.1. Map of study area (v. Momotove, Kharkiv region, Ukraine, 2017).
Source: Google and Bing Satellite Imagery [12]

RESULTS AND DISCUSSIONS

The study area with appropriate slopes has been chosen among many others in north-eastern direction from Harkiv town, Kharkiv region, Ukraine.
The soil, located on the slopes of the "Balanchivka" ravine of the Forest Steppe Left Bank, is presented by *chernozem*

podzolized on loess parent material and has the following morphometric description of the south (S) and north (N) slopes horizons [11].

First horizon Hd 0-16 cm (S); 0-20 cm (N) – arable, porous, dust-lumpy, has a dark gray color with inclusions of plant roots, there are noticeable signs of SiO_2 along the entire profile length, the transition to next layer is unmarked. Next horizon He 16-45 cm (S); 20-60 cm (N) – humified, slightly eluted, more compacted with structure in comparison with the previous horizon, moist, heavy-loamy, with a slightly marked transition. Horizon Hi 45-80 (S); 60-90 cm (N) - slightly illuvial, less humified, moist, compacted, dark gray with the noticeable transition. Horizon Hp 80-106 cm (S); 90-130 cm (N) – upper transitional, less humified, compacted with some marks of colloidal traces along the edges of structural elements, dark gray color, transition noticeable. Horizon Ph 106-138 cm (S); 130-170 cm (N) - lower transitional, partly humified, dark gray color, with more thick structure, some marks of colloidal traces along the edges of structural elements, noticeable transition to the next horizon. Last one horizon P 138 cm (S); 170 cm – is a parent material, a light brownish color, slightly humified, gley loess.

This type is considered a high-fertile soil situated on the Left-Bank Forest Steppe and is most commonly observed within the right banks of rivers. It is suitable for growing all kinds of agriculture crops, but because of the location on high gradient slopes (10-15 degrees) is widely used as hayfields and pastures with limited grazing. For the analysis of soil, samples were taken in the middle of the slopes of different exposure (north and south), located opposite to each other.

The main differences between *chernozem podzolized* types on different slopes included deeper soil profile length on north slope with approximately the same thickness of the soil horizons.

The laboratory analyses result of soil samples horizons-wise given in Table 1.

In 1987 the humus content for the north exposition slope were for horizons (%): Hd – 6.80; He – 5.45; Hi – 4.10; Hp – 2.66; Ph – 1.55. Same values for south orientation soil horizons were lower (%): Hd – 3.55; He – 2.66; Hi – 1.80; Hp – 1.30; Ph – 0.60.

Table 1. Soil fertility parameters for horizons of *chernozem podzolized*, v. Momotove, 2017

Soil horizons	Humus content, %	Soil fertility content			pH
		NH_4 mg/100g	P_2O_5 mg/100g	K_2O mg/100g	
North exposure slope					
Hd	6.46	45.49	2.44	78.33	5.85
He	6.24	37.42	2.00	66.28	5.81
Hi	5.61	31.91	1.53	69.29	5.90
Hp	4.97	30.66	1.22	72.30	5.85
Ph	2.43	29.07	0.84	93.39	5.85
South exposure slope					
Hd	4.76	43.51	1.42	84.35	6.12
He	4.13	35.50	1.33	90.37	6.20
Hi	3.49	26.31	0.94	90.37	6.23
Hp	2.96	27.80	0.81	90.37	6.33
Ph	2.01	27.26	0.50	66.40	6.43

Source: authors analyzation and calculations.

The soil aqueous solution reaction values were distributed somewhat differently. Thus, for the slope of the north exposition along the horizons in 1987 they were: Hd – 5.95; He – 6.0; Hi – 6.1; Hp – 6.0; Ph – 6.15. Same pH-values for south orientation soil horizons were higher: Hd – 6.15; He – 6.30; Hi – 6.40; Hp – 6.40; Ph – 6.62.

According to this such soil type has an average soil fertility level and is typical for conditions of Left Bank Forest-Steppe of Ukraine.

After taking into account the humus values and the reaction of the soil aqueous solution, the corresponding comparative diagrams of their values have been plotted over the horizons.

The soil data obtained from the analysis indicates a slight humus content decrease in the arable layer on the north faced slopes, while the humus content is increasing along other horizons and along the entire soil profile. The difference in humus content between the north and south exposure slopes fluctuates by several percents at the top of the horizon.

Due to changes in the reaction of the soil solution, a slight decrease in the soil solution response rate was observed in all horizons. Thus, the pH of the north slope was lower than that of the south slope, and in the context of 30 years period, there is a well-defined tendency to increase of the actual acidity in the soil.

Diagrams of parameters are presented below. (Fig.2)

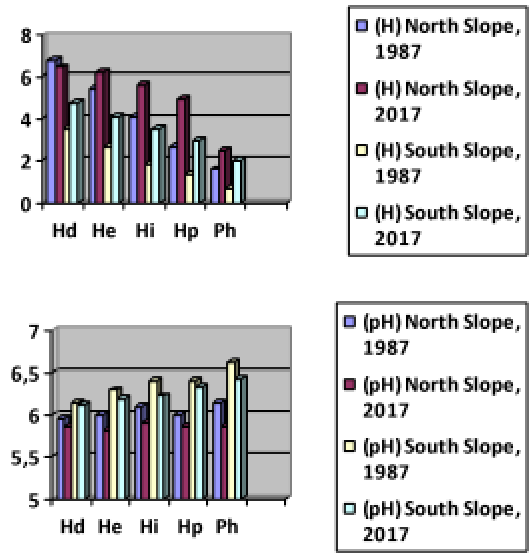

Fig. 2. Comparison of humus content (h) and the reaction of the soil solution (pH) values in 1987 and 2017 years.
Source: authors calculations and archival data [9].

The humus indicator reflects the content of nutrients for plant agglomerations on the hillside. The changing of the soil solution reaction towards acidification indicates increased assimilation of anions, which deteriorate the conditions of mineral nutrition. This also hinders the intake of calcium into plants, slows down the synthesis of proteins and sugars.

The study of issues regarding the improvement and preservation of natural forage considers the principles of ecology and biogeocenology - fullness of phytocenoses, economical and ecological complementarity of species, their different reaction to the influence of factors, etc [1, 3, 10]. In order to formulate a general idea about quantitative and qualitative aspects of the botanical composition present in grasses covering the slopes, we have systematized species belonging to certain genus and families. A survey of hillsides with various exposition of “Balanchivska” ravine indicates that the number of herbaceous plants included more than 70 species belonging to 13 orders, 21 families and 56 genera.

The largest number of them are of the legume family (Leguminósae) - 15 species. They also had the largest number of genera, which is the evidence of their high taxonomic and genetic diversity.

The second place was occupied by asters (Asteraceae) – 11 species, the third – grass cereals (Poaceae) – 9 species, the fourth – lip-flowers (Lamiales) – 7 species, the fifth-sixth – rose family (Rosaceae) and figwort family (Scrophulariaceae) – 4 species, the seventh-nine – buttercup (Ranunculaceae), umbrella (Umbellíferae) and forget-me-not (Boraginaceae) family – 2 species, tenth-eleventh – milkweed (Euphorbiaceae) and violets (Violaceae) – two species, but in each of two families.

Thus, legumes accounted for 21.5% of the botanical composition, asters – 15.7, grass cereals – 12.9, lip-flowers – 10.0, roses and figworts – 11.4, umbrellas and forget-me-nots milkweed and violets – 14.5 and the last ten families accounted for 14% of the total families.

During the years of experiments, among the grass cereals the most spread were such species as meadow bluegrass – Poa pratensis, couch grass – Agropyrum repens L., hungarian brome grass – Bromopsis inermis (Leys.), koeleria (or junegrass) – Koeleria delavignei Czern. et Domin, meadow fescue – Festuca pratensis Huds., volga fescue – Festuca sulcata Hack. та інші. Legumes were presented with alfalfa medica – Medicago romanica Prod., birds-foot trefoil – Lotus ucrainicus Klok., esparcet (Arenaria) – Onobrychis arenaria (Kit.), sweet clover – Melilotus officinalis (L.) pall, yellow alfalfa – Medicago falcata L., purple-globe clover – Trifolium alpestre L., mountain trefoil – Trifolium montanum L та іншими видами. Among the motley grass are common yarrow – Achillea millefolium, meadow sage – Salvia pratensis L., sagebrush wormwood – Artemisia campestris L., narrowleaf plantain – Plantago lanceolata, St John's-wort perforate – Hypericum perforatum L., leafy spurge – Euphorbia virgata Waldst. et Kit., brown knapweed – Centaurea-jacea L., white cinquefoil Potentilla alba L., sickleweed (longleaf) – Falcaria vulgaris Bernh., dwarf everlast – Helichrysum arenarium (L.) DC, clustered bellflower – Campanula glomerata L., common dandelion – Tarahacum officinale Webbex Wigg., mouse-ear hawkweed – Hieracium pilosella L., wild thyme -Thymus serpyllum L., viper's bugloss - Echium vulgare L., common gypsyweed – Veronica officinalis L., sour weed – Rumex acetosella L., fern-leaf dropwort – Filipendula vulgaris Moench., austrian wormwood – Artemisia austriaca Jacq., bird's-eye speedwell – Veronica chamaedrys L., common chicory – Cichorium intybus L. and others [7]. The next part of the study was the selection of typical vegetation clusters in relation to the regime of humidity and temperature on the example of cereals, legumes and herbs. After that, the differences between the characteristics of these phytocenoses on the slopes of different exposures were refined by clarifying the botanical composition of the natural herbage and hay crop by mowing.

It should be noted that among the plants with higher fodder value, the following species of cereal species were identified: meadow bluegrass, couch grass, hungarian brome grass, koeleria (junegrass), volga fesque and meadow fesque. Legumes were presented by yellow alfalfa, birds-foot trefoil, purple-globe clover and mountain trefoil and other species. Most species were of low-grade quality for foraging. The results of the ecological analysis confirmed that the main part of the species - mesophytes.

It also should be noted that during the botanical composition survey in 1987-1989, for an average of two years in the south exposition cereal grass species composed 52.9%, legumes - 8.9, and motley grass - 38.3%, and north respectively 54.1; 6.8 and 39.1%. In 2017 and 2019, we also determined the botanical composition of the herbage in both the south and north slope exposition (Table 2). Analysis of studies shows that, after a long period of time, compared to previously obtained results, the average number of cereals in the south exposition decreased by 3.1%, compared to the previously obtained results for the period 2017-2019, by 2.2% in the north 3.1%, however, the share of legumes, by contrast, increased by 2.2 and 3.1% respectively. The number of motley herbs increased slightly and was the same in both exposures (39.4%).

Table 2. Botanical composition of natural grass on slopes of different exposure, %

Production valuable groups of herbs	Years of study		Average for two years
	2017	2019	
South orientation slope			
Cereal grass	51.2	48.4	49.8
Legumes	9.4	11.2	10.3
Motley grass	39.4	40.4	39.9
North orientation slope			
Cereal grass	52.2	51. 6	51.9
Legumes	8.4	10.2	8.9
Motley grass	39.4	38.2	38.8

Source: authors analysation and calculations.

It should be noted that in determining the species composition of herbage in 2017-2019, we noted its slight changes compared to the previous survey. The number of herbs present in certain phytocenoses and some species increased slightly, namely there is an additional presence of such mezophites as false hellebore – Adonis vernalis L., erect cinquefoil – Potentilla erecta (L) Raeusch and comnion burnet – Poterium sanguisorba.

After a period of research in 2017 and 2019, we also determined the hay yield, which in the south exposition was higher than the average in 1987 at 0.08 t/ha more and equaled 1.77 t/ha, and in the north by 0.11 t/ha and equaled 2.09 t/ha. The distribution of grass yields by slopes was chosen as an indicator to characterize the productive properties of grasses. It allowed us to have a clue about the capacity of plant mass during the growing season, which is extremely important for planning the process of supplying livestock with green mass and the proper organization of work during hay harvesting. In our studies, the soil and climatic conditions contributed to two times haymaking activity instead of a single one (Table 3).

In our experiments, the first haymaking is usually obtained in the first decade of June and the second in late summer, or in the first decade of September. In the experiments conducted in 1987-1989, for an average of six years, in the south exposition, the first haymaking contributed 77.9%, and in the north 77.1% of the total hay harvest for the season, the rest accounted for the second haymaking (22.1-22.9%).

Table 3. Hay yield on slopes of different orientation, t/ha

Hay yields on slopes after two hay-makings					
2017		**2019**		**Average for two years**	
First hay-making	Second hay-making	First hay-making	Second hay-making	First hay-making	Second hay-making
South orientation slope					
1.38	0.34	1.40	0.42	1.39	0.38
North orientation slope					
1.60	0.42	1.64	0.52	1.62	0.47

Source: authors analysation and calculations.

In assessing the yield of natural hayfields in 2017-2019, it was also confirmed that the main part of it was the first haymaking, namely at the south exposure of 1.39 t/ha (78.5%) and at the north - 1.62 t/ha (77.5%). It should also be noted that the average hay yield for 2 haymaking at the north exposure was higher by 0.31 t/ha (18.1%) over the 2017-2019 average.

CONCLUSIONS

It was determined for *chernozem podzolized* what for a slope with north exposure the higher percentage of humus along all soil horizons, except for the upper one, indicates a higher potential yield than on the south exposure slope, that is confirmed by the yield data for all slopes of 2017 and 2019. Among the plant communities that prevailed on both slopes, the first place is occupied by grass cereals, the second place – by motley grass, and the last - by legumes. Appearance in 2017 of some new herbs belonging to mesophytes that are adapted neither to a particularly wet nor a particularly dry environment indicates on potentially appropriate biogeocenotic conditions.

Our research clearly shows the possibility of involving such slope areas of *chernozem podzolized* in hay-making production within a soil-protective land use strategy.

In spite of low-grade herbs quality for foraging, there is a stable profit of two hay-makings during a season and creation of stable vegetation cover to prevent erosion processes on hillslides.

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