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Ecological Fertility Model of Grey-brown Soils Under Pacture in the Gobustan Massive of the Azerbaijan Republic

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Abstract

An application of the adaptive-landscape agricultural system directed to the durable activity of the natural and agroecosystems is possible by the agroecological evaluation of soils, system analysis, use of the modelling methods. Rational use of the pastures, restoration of the unfit areas and protection intensifying are prinsipal duties standing before the state considering an important role of the pastures in the environment protection and as a fodder base in the cattle-breeding development. The mountain grey-brown soils under pactures of the Gobustan massive in the Azerbaijan Republic were taken as a research object. A total area of the zone is 120970 hectares. The winter pasture areas from them are 76875 hectares. The ecological fertility model consisting of five blocks (ecology, soil composition, soil properties, plant, agromelioration) of the mountain grey-brown soils under pastures in the Gobustan massive was worked out based on N. N. Rosov, D. S. Bulgakov, L. L. Shishov, D. N. Durmanov, I. I. Karmanov's methodic directions. The ecology block includes climatic and relief indicators of this territory. In blocks of soil composition and properties of gray-brown soils under pastures, data on the particle size and the organic composition of soils, as well as the agrophysical and agrochemical properties of the soils of the studied soils, are collected. The plant block contains geobotanical data on phytocenoses. Using this model together with the methods of rational use of pastures, it is possible to increase the productivity of Gobustan winter pastures and contribute to the development of cattle breeding in this region.

Keywords

Fertility Model, Winter Pasture, Gobustan, Mountain Grey-Brown Soils

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1. Introduction

Performance of the complex researches about cultivation condition, composition and properties of soils, soil fertility intensifying and increase of agrocenosis productivity by considering a need of plants for the environment is one of the important problems in soil science [1]. The human's influence on biogeocenosis by agriculture, forest and water economy requires a manacement of biosphere and its components as a scientifically grounded form.

At present an investigation of the complicated systems as biocenosis requires an establishment of the conseptual model of the object, i.e. an expression of its structure, functions and mutual relations by a word, graphic, formula and figures by an application of the systematic approaching method. One of the main methods is considered modelling. It is impossible to solve an increase of soil or landscape productivity in biocenosis by any method without an application of the complex methods. The soil which is one of the main structural parts in present development level of science and technics is a controllable component. The human can control

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water ecosystem and organisms a little (by the soil), but he can't interfere in atmosphere and climate.

So, it is necessary to possess a reliable scientific base about the same soils for solution of the problems about fertility management. Establishment of the soil fertility models in a various level gives an opportunity for such bases creation on the basis of the information methods [2].

We should take into account that the laws of life "Nature harmony" act in the natural landscapes and at this time a substance, energy and information exchange is an equivalent form among the ecosystem components.

But this energy, substance and information balance in agroecosystems are disturbed in some or other direction as a result of the long anthropogenic effect. We consider expedient to perform natural biogeocenosis investigation (including pasture biogeocenosis) on three circle in connection with the hierarchical chain in the nature: soil – plant – landscape system. In this connection the researches system should be performed on each structural part (object) [3, 4]. A main object of the research is soil-complex and open functional dynamic system and its composition, properties and regimes must be investigated.

The second object –plant (phytocenosis) is a substance transporter and it has a crop producing ability. Here the plant reaction to the soil character and regimes is studied from standpoint of product quality and quantity.

The third object of the research is landscape (geological base, soilforming rocks, land relief, climate, hydrothermic condition). Here the landscape is studied considering as a general background in hierarchical connection with biogeocenosis.

An ecological fertility model of soils under pasture is a blocked schematic structure of learning of the mutual relation complexity of the soil-plant-landscape system with the anthropogenic factors by applying a system approach [5]. The blocks are formed from the factors, elements and indications which reflect a direction of the changes appearing as a result of the natural processes and anthropogenic influence, importance, quality and quantity character of biogeocenosis components.

The ecological fertility model of soils under pasture is formed from five blocks differing for the significance degree, importance in fertility management: ecology block, soil composition block, soil properties block, plant block, agromelioration block [6].

The ecology block is formed from two half-blocks: a climate and relief. The relief half-block is formed from the following factors: relative and absolute height, inclination and exposure of the slopes, subsoil waters level, horizontal and vertical distribution of the air flows.

The blocks of soil composition and soil properties play a leading role in the structure of the ecological model. These blocks provide information on the limiting factors of soil fertility. Soil cover offers all necessary facilities for photosynthetic activity of plants providing the cultures feeding with mineral, water, carbon gas and nutrient (NPK).

The soil composition block is separated into 3 half-blocks: granulometric composition, organic composition, chemical composition.

The granulometric composition possesses an integral function in formation of the soil agronomic characters, it determines water, air and heat regimes of soil, the organic composition reflects a rated quantity and supply of humus. A sum of the absorbed bases with mg-eq/100g of soil and mineral biogenic elements- nitrogen, phosphorus, potassium percentage quantity and reserves include the chemical composition. The soil properties block concentrates agrophysical and agrochemical properties in itself.

The geobotanical information about the plant types, spreading in the pasture areas which are investigated in the plant block, phytocenoses, main fodder plants is collected. The analysis results about a biochemical composition of phytocenosis, general productivity and productivity on botanical-economic groups of the plant formations, botanical kind composition and structure of the main plant groups are collected, a category, capacity, the level of suitability and use norm of the pastures are determined.

In agromelioration block have been collected the superficial and fundamental improvement measures directed to the rationally using the soils under pasture and improvement of water and air regimes, soil composition.

2. Research Objectives and Methods

The mountain grey-brown soils under pasture of the Gobustan massive in the Azerbaijan Republic have been taken as a research object. A total area of the Gobustan massive is 120970 hectares. The winter pasture areas are 76875 hectares. To fulfil the duties in connection with the research work, the support stations have been selected in the main soil types and sybtypes and in plant phytocenosis on them, 45 soil cuts have been put and the field researches have been performed in the selected support stations in 2014-2018. The laboratorial analyses of the soil and plant samples taken from the winter zones have been performed.

The physico-chemical analyses of the taken soil samples have been performed on generally adopted methods, while

studying the plant cover, the following methods have been used during an application of phytocenosis botanical properties, definition of the fodder areas productivity and geobotanical and cultural-technical researches: Iglovikov and others, L. G. Ramensky, I. A. Tsasenkin [7-9]. Establishment of the fertility model of soils under pasture was performed on the basis of N. N. Rozov, D. S. Bulgakov, L. L. Shishov, D. N. Durmanov and I. I. Karmanov's methods [10-13].

3. Analysis and Discussion

The mountain grey-brown soils spread in the north-western part of the Gobustan massive, in Hacivally winter hut, Garagobu mountain, Jangi pass. A total area these soils is 13065,0 hectares (10,8%). These soils develop in arid steppe zone, at 500-800 m height of sea-level, low mountainous and intermountain plateaus inclined to north, north-east and on the calcareous and gypsum loams. The mountain grey-brown soils are divided into three kinds according to the analysis consequents and density of the granular soil layer; thin mountain-grey-brown soils- 1092,5 ha, medium density mountain grey-brown soils-9120,0 ha and dense mountain-grey-brown soils-2852,5 ha. Diversity of the soils differing for mechanical composition (clayey, heavy loamy, mean loamy, light loamy) and washing degree (weekly washed, mean washed) spread in the zone.

3.1. Ecology Block

The ecology block is formed from two blocks: relief and climate blocks.

Relief half-block. The intensively crushed elements consisting of little shattered low mountainous and inter-mountainous plateaus, inclined slopes, wave-like-hilly slopes are found in the zone with mountain grey-brown soils of the Gobustan massive. The separate parts of the zone differ from one another, because one is higher than other. The rivers creating gorges, ravines, mountains, deep valleys play a great role in the relief condition complexity. The height parameters change at 500-800 m height from sea-level (Table 1).

Table 1. Ecology block parameters of the mountain grey-brown soils under pasture.

Indicators	Parameters
1. Relief	
Relief condition	Intermountainous and upland plateau
Height, m	500-800
Subsoil water level, m	-
2. Climate	
Sum radiation, kcal/cm^2	125-130
An average annual temperature of the weather, °C	12,5
July temperature, °C	24,0
January temperature, °C	1,4
Rainfalls, mm/year	385
Evaporation, mm/year	994
Humidity coefficient, HC	0,39
Humidity index (Md)	0,15-0,20
10°C a sum of high temperatures, °C	3000-4000
A quantity of the frostless days	200-240

Climate half-block. A climate of the winter pastures where the mountain grey-brown soils spread is moderate-warm arid subtropical. The Great Caucasus mountains render their influence on Gobustan climate formation from north, the Caspian sea east and the Kur-Araz lowland from south-west. The hottest month is July-August. The July month temperature is 24,0°C, the coldest month- January temperature is 1,4°C. An average annual temperature of the weather is 12,5°C.

Provision with the sun radiation which is a main source of the energy processes occurring in plants is enough degree - 125-130 kcal/cm^2. The thermic supplies of the zone are high: 10°C high temperatures sum is 3000-4000°C. A quantity of rainfalls grows while rising the height -385 mm/year. The weather is warmer in summer, evaporation is 994 mm/year. The humidity coefficient is 0,39, the humidity indication (for A. J. Eyyubov) is 0,15-0,20 and it indicates that, the zone concerns arid climate zone. A quantity of the frostless days is 200-240 days. The north and north-east winds are characteristic for the Gobustan zone. The north wind is dry and blows for some days. The mountainous-valley winds blow in connection with the complex relief of Gobustan.

3.2. Soil Composition Block

The soil composition block is formed from incontrollable parameters (granulometric composition) and practically hard controllable parameters (organic and chemical composition) and allows to work out the measures directed to define soil fertility level and fertility increase.

The granulometric composition determines the root system development, spreading depth and directly affects its branching. From the morphological description of the cuts taken in the research object it is clear that a color of these soils is cinnamon on the upper layers, but brown and greyish-

brown on the low layers. Its structure is heaplike, granual-heaplike [14]. It is seen from the analysis figures that these soils are clayey, heavy and mean loamy in a mechanical composition. So, a quantity of physical clay is (<0,01 mm) on the upper layers-35,2-67,04%, but 46,24-61,32% along the profile (at 0-100 cm layer). The silt fractions number is 12,53-17,72% along the profile (0-100 cm) (Table 2).

Table 2. Indicators of the soil composition block in the mountain-grey-brown soils under pasture.

Indicators	Interval	M
1. Granulometric composition: 0-100 cm		
<0,01 mm, %	46,24-61,32	54,47
<0,001 mm, %	12,53-17,72	15,28
2. Organic composition:		
Humus % 0-20 cm	1,47-3,37	2,21
t/h	34,99-80,21	52,60
% 0-50 cm	1,14-2,57	1,68
t/h	73,53-165,77	108,36
% 0-100 cm	1,01-2,16	1,35
t/h	134,33-287,28	179,55
3. Chemical composition: (0-50 cm)		
Nitrogen, %	0,09-0,23	0,16
t/h	5,81-14,83	10,32
Phosphorus, %	0,12-0,30	0,22
t/h	7,74-19,35	14,19
Potassium, %	2,21-2,66	2,45
t/h	142,54-171,57	158,025
Sum of absorbed bases, mg-eq/100g of soil		
0-20 cm	17,56-31,80	25,47
0-50 cm	18,40-39,24	27,66
also, Ca^{2+}	13,87-31,32	21,85
Mg^{2+}	4,03-7,17	5,21
Na^{+}	0,5-0,75	0,6

The grey-brown soils under pasture differ from the other soils in the zone for their dark color and richness with organic substances. So, a total humus quantity is 1,47-3,37% on the upper layer, 1,14-2,57% at 1 meter-layer along profile. Humus is tautened towards low layers of humus profile. Humus supply is 134-287 t/h at a metric layer. A total nitrogen number concerning humus is 0,09-0,23%, but its supply is 5-15 t/h. This soils aren't rich with phosphorus and potassium much as one needs. A total phosphorus and potassium number is 0,12-0,30% and 2,21-2,66% at half-metric layer.

The mountain-grey-brown soils under pasture of the Gobustan massive are rich in absorbed bases. A quantity of absorbed bases is less on the upper layers than on the low layers in the analyzed sections. So, their number is 17,56-31,80 mg-eq/100g of soil at 0-20 cm layer, but it is 18,40-39,24 mg-eq/100g of soil at 0-50 cm layer. If we look over cations quantity separately we can see Ca^{2+} superiority: 13,87-31,32 mg-eq/100g of soil (75-80%). Being little of absorbed Na^{+} indicators: 0,5-0,75 mg-eq/100g of soil (1,9-2,71%) shows that these soils aren't solonetzificated.

3.3. Soil Properties Block

The agrophysical and agrochemical indices of mountain-grey-brown soils under pasture of the Gobustan massive have been collected in the soil properties block.

If we consider a quantity of the agronomically valuable water-resistant aggregates, it is evident that a structural level of the mountain-grey-brown soils can be appraised with satisfactory (43-55%), these soils possess a structure of the heap-like micro aggregate type according to a structural situation [15]. The structural composition of soils deteriorate on the slopes as a result of erosion in the investigated zone. (>0,25mm) water-resistant aggregates number is little (30-35%) is strongly washed soils.

Agrophysical properties

A density index of soil is considered a main physical property of the soil which determines necessary agricultural technology. The density indices of the mountain-grey-brown soils under pasture grow along profile: 1,30-1,35 g/cm^3 at 0-100 cm layer, while it is 1,16-1,22 g/cm^3 at 0-20 cm layer. The mountain-grey-brown soils porosity is agronomically appraised with satisfactory (48-50%) because the soil porosity is in a functional dependence with its density and special weight.

The water-physical indications of the mountain-grey-brown soils under pasture change in the following limits getting a satisfactory mark depending on colloids quantity, porosity quantity and quality, structure formation level and physical-chemical characters. Hygroscopic humidity-4,5-5,9%, total water capacity-22-30%, productivity humidity-12-16% (Table 3).

Table 3. Indicators of the soil properties block in the mountain-grey-brown soils under pasture.

Indicators	Interval	M
1. Agrophysical properties:		
Water-resistant aggregates, >0,25 mm, % 0-100 cm	43-55	49
Density, г/см^3 0-20 cm	1,16-1,22	1,19
0-50 cm	1,27-1,31	1,29
0-100 cm	1,30-1,35	1,33
Porosity, % 0-100 cm	48-50	49
Water permeability, mm/min		
Hygroscopic humidity, %	4,58-5,96	5,45
Total water capacity, %	22-30	26
Productivity humidity, %	12-16	14
2. Agrochemical properties:		
N/NO_3+N/NH_4, mg/kg (0-50 см)	7,69-13,49	10,95
P_2O_5, mg/kg	8,8-17,51	13,26
K_2O, mg/kg	183,49-302,59	260,21
pH, 0-100 cm	8,0-8,6	8,3
$CaCO_3$, % 0-100 cm	5,71-11,47	7,4
Dry residue, % 0-100 cm	0,06-0,25	0,17

The indices of the soil properties block in mountain-grey-brown soils under pasture: water-stable-aggregates, >0,25 mm,%, density, mm/minute, hygroscopic moisture, total field water capacity,%, productive moisture,%.

Agrochemical properties

A quantity of mineral nitrogen in the mountain-grey-brown soils under pasture (at 0-50 cm layer) is 7,69-13,49 mg/kg. A gradual increase of nitrate nitrogen quantity from July to Autumn is connected with the formation of the fit hydrothermal condition for nitrification process in the soil. The gross phosphorus number changes at 8,8-17,51 mg/kg limit on half –meter layer in the mountain-grey-brown soils under pasture.

A reaction of soil solution (pH) strongly influences on plant growing and state. The environment reaction is 8,0-8,6 in the investigated soil, and it shows that the soil solution is alkaline reaction. The soil calcareous informs its aridity and it is considered an important index of the soil heat regime which is good for the plant. The profile of the mountain-grey-brown soils is calcareous and its gradual increase towards low layers is observed, so a quantity of carbonates reaches 5,71-11,47% at 0-100 cm layer while it is 4,29-8,76% on the upper layers.

The surplus number of salts which are easily solved in dry residue detain development of the plants and root system. The dry residue quantity in the studied mountain-grey-brown soils is little and it changes in 0,06-0,25% limit at 1m-layer, this shows spreading of non-salinized and weakly salinized soils in the zone.

3.4. Plant Block

The dry steppe vegetation develops in the mountain-grey-brown soils of the Gobustan massive. The plant cover development is in connection with the relief forms and atmospheric rainfalls quantity in this zone and it is distinguished with the xeromorphic character of the plant cover [16].

A total area of the winter pastures spreading in the mountain-grey-brown soils of Gobustan is 12073,0 hectares. From them 6095,8 hectares (50,49%) are clean pasture, 608,7 hectares (5,04%)-bushy pasture, 5368,5 hectares (44,47%) – stony pasture. The stony pasture area is mostly found in the thin mountain grey-brown soils- (654,5 hectares) and middle-thick mountain-grey-brown soils 62% is clean pasture (1314,5 h), 23% (485,2 h) is stony pasture.

One type of the arid steppe vegetation was revealed in the research object: fescue- feather grass-wormwood (*Festuca sulcata; Stipa Szovitsiona; Artemisia fragrans*). Fescue and feather grass concerning the steppe vegetation, wormwood concerning the semidesert vegetation are adopted as edificatory of this pasture type [17]. The botanical-economic composition of the dry steppe vegetation of fescue- feather grass-wormwood is so: here 18 kinds of flowering plants have been noted. From them 2 kinds (11,11%) are bushes, 1 kind (5,6%)- subshrubs, 7 kinds (38.9%) grain, 2 kinds (11,11%)- leguminous, 6 kinds (33,3%)- forb group. The project cover is equal to 40-60%. A middle height of grass cover is-20-45 cm. Dominant of formation is *Festuca sulcate* (3-4 scores), subdominant- *Stipa Szovitsiona* and *Artemisia fragrans* (2-3 scores).

Fescue- feather grass-wormwood formation productivity is 12,48 cent/hectares on dry mass (Table 4). From them on the botanical-economical groups- grain grass productivity is 6,13 cent/h (49,12%), legumenious-1,64 cent/h (13,4%), forb-4,71 cent/h (37,74%).

Table 4. Productivity on the botanical-economical groups of the fescue-feather grass-wormwood plant formation.

Data	Formation	The botanical-economical groups	Productivity (dry mass)	
			Cent/h	%
Spring	Fescue-	Cereal	6,13	49,12
20-27 May	Feather grass-	Legumes	1,64	13,14
2015	Wormwood	Forb	3,01	24,12
Total			10,78	86,38
Autumn	Fescue-	Cereal	-	-
01-05 December	Feather grass-	Legumes	-	-
2015	Wormwood	Forb	1,70	13,62
Total			12,48	100

If we consider distribution of the fescue- feather grass-wormwood phytocenosis productivity on the botanical-economical groups, main mass of product will be cereal-6,13 cent/h (49,12%) and forb -3,01 cent/h (24,12%) in spring. In the autumn the crop increase happens at the expense of the forb, i.e. wormwood flowering after the autumn rainfalls (1,7 cent/h).

According to the analyses the nutritiousness of this plant formation as a fodder plant is higher in the spring, protein is 11,21% in spring, 8,08% in autumn, fodder unit is 49,4 kg in spring, 37,57 kg in autumn. A quantity of protein assimilated in fodder, which is eaten by the cattle is higher in spring (0,56 kg) in comparison with autumn (0,40 kg).

The fodder supply of the total pasture areas in which the fescue- feather grass-wormwood plant formation spread in Gobustan massive is equal to 181172 centner, 88774 kg fodder unit and 10146 kg digested protein by the eating dry mass calculation. One hectare load of such type of the pasture area is equal to 1,7 head sheep-goat.

3.5. Agromelioration Block

The appropriate measures system was worked out to provide the cattle-breeding with the fodder areas having higher

productive and qualitative, rich grass content in the investigated region [18]. Here includes, rationally using from pastures, superficial and radical improvement measures, establishment of the cultural pastures under the irrigative condition in the suitable areas [19].

Grazing in parts in the pasture areas and pasture circulation corresponding the soil-climate condition, correct distribution of the pastures load, using from the areas in optimal periods, definition of the grazing rule, etc. include the rational use measures [20]. The grazing performance for the pasture load is necessary in October-November months.

The following measures must be realized to use rationally from the winter pasture areas in Gobustan:

a) a head quantity of the small cattle for the pasture area must be determined correctly;

b) the grazing period should be considered corresponding the pasture type;

c) the weeds, injurious and poisonous plants (thorny, bushes) grown on the sheer slopes shouldn't be torn out to prevent from soils washing and erosion processes.

d) The cattle grazing must be prohibited on the slopes of which inclination higher than $10\text{-}15^0$, especially in the strong rainy days;

e) The use periods of the pasture areas must be seriously obeyed.

Clearing the small and middle diameter stones from the pasture areas, applying the organic and mineral fertilizers in pastures, levelling hillocks, filling hollows, sowing of the fodder plants seed corresponding to the sparse and eroded areas not ploughed soil surface before October, concern the surface improvement measures.

One of the most important fundamental improvement measures consists of washing of salts from the solonetzificated soils on the plain and less inclined slopes by the melioration methods in the winter pastures of the region farms. Fulfilment of melioration works increase the pastures productivity for 2-3 times.

4. Conclusion

According to the research results intensive performance of cattle-breeding not considering a natural condition and resources in the Gobustan massive of the Azerbaijan Republic was a reason for negative transformation, strongly deteriorating of the ecological condition. Strongly decrease of biodiversity in the degraded pasture areas, replacement of the plant species possessing a high nutritiousness with the less-eaten and poisonous kinds have been observed. An ecological fertility model of the mountain-grey-brown soils under pasture was worked out considering the soil-ecological characters of the natural pasture areas in the Gobustan massive. Productivity, feed supply and load on pastures of dry-steppe vegetation, growing on the gray-brown soils of the Gobustan massive of Azerbaijan have been calculated. It is possible to establish a hard fodder base for the cattle-breeding development in the region turning the winter pastures of Gobustan into productive phytocenosis by making suitable with the rational use of pastures and applying of the composed ecological fertility model in a complex form.

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