The influence of long-term agricultural use of soils of the dry subtropical zone of Azerbaijan on its morphological and agrochemical properties

Firoza Ramazanova Muxurovna
National Academy of Sciences of Azerbaijan, Institute of Soil Science and Agrochemistry, Baku, Azerbaijan,
firoza.ramazanova@rambler.ru

Abstract: *The aim of the research was to study the influence of natural vegetation and intermediate sowings of fodder crops on the formation in the profile of (WRB, 1998) Gypsisols and Gleyic Calsisols and Irrigated Gypsisols and Gleyic Calsisols soils of the dry-steppe and semi-desert zones of Azerbaijan genetic horizons. It has been established that significant morphological changes are common to the thickness of the humus horizon, the depth of carbonates and agrochemical parameters of the studied soils. Their maximum values in the arable layer are established in Irrigated Gypsisols and Gleyic Calsisols soils under the collection of 3 green mass crops per year from 1 ha: the thickness of the humus horizon increased to 0.25 and 0.27 cm, respectively, humus - up to 2.73 and 3.00%, the amount of absorbed bases - up to 25.71 and 30,80 mg-eq / 100 g of soil, mobile phosphorus - up to 30.9 and 34,00 and exchange potassium - up to 317.3 and 423,1 mg / 100 g of soil. In accordance with the WRB system (2015), Irrigated Gypsisols can be classified - Irragric Cambisols (Protocalcic, Clayic), and Gleyic Calsisols - Irragric Gleyic Calcisols (Calcic, Loamic).*

KEYWORDS: *HORIZON THICKNESS, HUMUS, ABSORBED BASES, MOBILE PHOSPHORUS, EXCHANGE POTASSIUM, AGROCHEMICAL PROPERTIES*

1. Introduction

Human economic activity, as a factor of soil formation, affects the soil-forming process both directly and indirectly through other factors, taking on the leading functions of regulating the interrelation between soil and cultivation crops[1].Some researchers believe that a natural zonal soil formation process occurs in arable soils, which does not differ from the process under natural vegetation, while others point at profound fundamental changes in the natural soil formation process [2].The transformation of natural biocenoses into agrocenoses is always accompanied by a change in morphological and physical parameters, as well as the qualitative and quantitative composition of organic residues. A quantitative account of such changes makes it possible to determine the speed and direction of soil formation processes [3].Accounting for the content and reserves of nutrients, their distribution in the soil profile makes it possible to establish the amount of available nutrients for crops, their biogenic accumulation, the direction of migration and participation in the biological circulation of elements, which is very important for increasing agricultural production in the dry subtropical zone of Azerbaijan.

The aim of the study is to assess changes in the morphological and agrochemical parameters of soils in the dry subtropical zone of Azerbaijan under the influence of their long-term agricultural use.

2. Prerequisites and means for solving the problem

The studies were carried out in 1998-2018. on virgin (Gypsisols, in WRB 2012) and irrigated gray-brown (Irragri Gypsisols, in WRB 2012, Absheron) and meadow-serozem (Gleyic Calcisols and Irragri Gleyic Calcisols, in WRB 2012, Kura-Araksin lowland) soils according to the scheme:1. virgin land *(Carex pachystylis, Poa bulbosa, Caragana frutex, Alhagi, Artemísia, Sálsola), 2. Secále cereále → Zéa máys; 3. Medicágo; 4. Zéa máys (spring sowing); 5. Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa; 6. Hórdeum* (for grain, farm sowing). Cultivation agrotechnics - zonal with some changes for each option. Repetition - 4-fold, plots area -72 m2. The climate is subtropical with dry hot summers, the amount of active t^0 is 4500 - 48480C, the arrival of FAR is 120-133 kcal / cm2, the amount of precipitation is 180 - 330 mm per year; days with air t^0> 100-285-330 and soil> 50 -315-360.

The laying of soil sections, their description, the selection of soil samples and the establishment of the preliminary classification name of the soil in the field were carried out according to the *Guidelines for Soil Description* (FAO, 2012) and according to the methods[4-7].

In soil samples, the following were determined: humus, mobile compounds of phosphorus and potassium, pH, carbonates [8]. Based on morphological and physicochemical properties, the name of gray-brown and meadow-serozem soils was given according to the International Soil Classification based on the Abstract Base (WRB) 2015[7].

Virgin and irrigated gray-brown soils (Gypsisols and Irragri Gypsisols, in WRB 2012) are located at an altitude of 50-165 m above sea level, geographic coordinates - 40 ° 28'871 "N and 49 ° 39'969" E, and meadow-sierozem soils (Gleyic Calcisols and Irragri Gleyic Calcisols, in WRB 2012) - located at an altitude of 48.80 m above sea level, geographical coordinates - 40 ° 29´37.689 "N and 47 ° 43´34.456" E.

3.Results and discussion.

The morphological features of the soil profile are a stable external characteristic of soils, and even a short-term anthropogenic influence on the soil leads to changes in morphological features [9]. That is, a plow horizon is formed, with characteristic features that differ from the original genetic horizons of natural soils and is a cultivated horizon with the preservation of the zonal appearance [10, 11]; it affects the direction and intensity of soil formation.

Gypsisols and Irragri Gypsisols. Studies have established that significant changes in the morphological profile of the soil are manifested mainly in the form of an increase in the humus horizon, the depth, as well as the thickness of the carbonate layer. These changes increase on the sowing of row crops, permanent cultivation of barley and on virgin soil, where the depth of occurrence of carbonates is higher, which is associated with higher evaporation from the surface associated with the thinning of the vegetation cover.

Permanent sowing of *Hórdeum* (variant 6) reduces the thickness of the humus horizon of the soil due to the low input of fresh organic matter into the soil. In all studied variants of the experiment in accordance with the "Classification and diagnostics of soils of the USSR" [12] and FAO 2015 [7] - Gypsisols and Irragri Gypsisols - thin, low-humus, which shows the homogeneity of the soil cover of the experimental area.

For the sample, we present a morphological description of the soil profile of section **No. A-12** (according to WRB-2015), laid down in the 5th option. The territory is located in the Experimental Economy Research Institute of Fodder, Meadows and Pastures of the Ministry of Agriculture of Azerbaijan, 500 m from the Baku-Shemakha highway, at an altitude of 87 m above sea level, geographical coordinates - 40028'26.37 "N, 49039'38 , 81 "E. SU, 27 ° C; WC - 2, LP - <100. Soil - Irragri Gypsisols.

The parent rocks are highly gypsum-bearing clayey deposits of deluvial origin and weathering products of tertiary clays. AA4M, IB, IF, vegetation: *Secále cereále + Vicia sativa + Brássica nápus*

→ Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa, ST, Hp - 0-25 cm.

A' 0-25 10 YR4/2, N, CL, GR, PD3, M (2-5 mm) и C (> 25cm 5mm), (M - < 2mm –200, > 2mm->20), F - 0.5 -2 mm, E,M, M –15-40%, ca, *pF-3, SC, MO 2-10% и N, ST, SC;

A" 25-53 10 YR5/2, CL , PD3, SB, FRF, AS, E, M - 15- 28cm 40%, C, F, MO 2-10% и N, PM, ca,P, I;

B 53-77 10 YR 4/6, CL, FM, FRF, M –2-5 mm, VF- < 0.5 24 cm mm, C, F-0.5-2 mm и F --< 2mm -20-50% и > 2mm-2-5%, ST 10-25, ca, PM, HA, *pF 3-2, D;

B/C 77-117 10 YR 5/4, CL, PD3, CR, F- 0.5-2 mm, 40 cm VF -< 0.5mm, F –0.5-2mm, C, ST 10-25%, PM, SL 0-5%,C;

C 117-129 7.5 YR 4/6, CL 25-40% silt, PD4, F - 0.5-2mm, 12cm MO 2-10%, VF, SC, SL, ST, N, S, pF*-3, V – < 2%, C;

C 129-152 2.5 YR 8/3, CL, LU, PD4, SC , MO 2-10% 23 cm and N, CS, F.

The results of the morphological description of section №A-12 show that the thickness of the arable horizon (0-25 cm) is 25 cm. The profile of this section up to the Cca horizon (117-129 cm) is described by the main tone 10YR, and in the Cca horizon (117-129 cm) - in a tone of 7.5 YR, deeper - in a tone of 2.5 YR [14].
In the morphological description of the soil profiles of other variants of the experiment, the following horizons were established: A' from 22 to 24 cm thick; A"- from 35-49 to 51 cm; B - from 57-65 to 75 cm; B/C - from 100 cm to 113 cm and C - from 121-129 to 148 cm, which corresponded to the statistical parameters of the morphological properties of the gray-brown soils of the Absheron Peninsula (Table 1). The middle of the soil profile consisted of transitional horizons (from humus to parent rock - B, B/C and C. Their total thickness in virgin soil was 64 cm, *Secále cereále → Zéa mays* - 49 cm, *Hórdeum* (farm sowing) - 64 cm. The Significant level of the occurrence of carbonates is noted under Hórdeum (65-119 cm), slightly under the Zéa máys of spring sowing (110-120 cm) and is lowered to a depth of 129-152 cm in variant 5.

In variants 3 and 5, the root system of *Medicágo* and grass mixtures (variant 5) intensively used moisture from the layer of 0-51-53 cm and thereby slowed down the rising migration of carbonates. For 20 years, the capacity of A' under *Hórdeum* (farm sowing) was 22 cm, under *Medicágo* - 24 cm, and the highest - under variant 5 (25 cm). This is completely logical - the different depth soil cultivation, depending on the type of intermediate mixed sowing of crops, in order to obtain 3 harvests of green mass per hectare per year, different depths of penetration by the root system of crops and the year-round supply of fresh organic matter of grass mixtures contributed to the approach of soil formation processes to virgin analogues.

Table 1: *Agrochemical indicators for the genetic horizons of the morphological profile of gray-brown soil*

Variant	Horizon, см	Power, cm	pH of water	Hhumus, %	mg-eq/ 100 g of soil		mg / kg soil	
					Ca	Mg	P2O5	K2O
	A'	0-22	7,9	2,19	14,34	9,50	20.0	242.8
	A"	22-50	8,9	1,28	10,78	9,36	16.0	203.0
	B	50-75	9,2	0,98	8,40	10,22	14.0	157.3
	B/C	75-100	8,0	0,50	6,95	7,90	5.3	110.5
	C	100-122	8,8	0,10	6,85	3,95	-	37,9
1	A	0-13	8,1	1,96	15,0	7,36	11.7	226.6
	A	13-35	8,6	1,34	12,75	11,40	7.00	211.0
	A/B	35-57	8,8	0,67	11,25	5,86	5.7	161.3
	B	57-100	8,4	0,38	6,88	8,11	2.00	152.3
	C	100-121	7,8	-	7,81	4,34	0,42	22,6
2	A'	0-23	8,2	2, 13	16,24	7,55	18.0	227.0
	A"	23-50	8,6	1,27	12,39	6,45	14.0	195.7
	B	50-75	8,9	0,61	9,44	5,28	11.7	144.3
	B/C	75-100	9,1	0,27	7,96	3,67	5.3	100.7
	C	100- 124	9,1	0,05	7,61	6,70	2,8	46,1
3	A'	0-24	8,0	2,51	20,60	10,99	27.8	269.5
	A"	24-51	8,6	1,60	19,76	10,55	20.0	231.2
	B	51-75	8,9	1,20	16,15	8,45	18.7	182.3
	B/C	75-113	8,5	0,52	11,61	4,67	10.6	131.5
	C	113-148	8,0	0,17	9,37	7,42	6,9	76,9
4	A'	0-22	8,3	1,88	14,97	5,01	15,6	215.4
	A"	22-49	8,8	1,10	11,75	4,66	12.9	178.5
	B	49-73	9,2	0,55	12,40	6,12	10.2	130.3
	B/C	73-110	9,0	0,15	11,36	4,51	3.7	74.6
	C	100-120	8,3	-	9,17	7,26	1,9	38,7
5	A'	0-25	8,4	2,73	21,25	4,95	30.9	317.3
	A"	25-53	8,8	1,72	20,40	4,45	25.7	241.0
	B	53-77	8,9	1,32	16,80	6,00	22,3	192,3
	B/C	77-117	9,0	0,71	13,80	11,0	17.0	140,0
	C	117 -129	8,0	0,17	10,87	6,08	10,4	92,1
6	A'	0-22	8,1	1,60	13,87	4,64	13.1	158.7
	A"	22-43	8,6	1,19	12,31	4,12	10.4	121.6
	B	43-65	8,8	0,60	11,75	4,66	5.0	77.9
	B/C	65-100	9,0	0,09	9,89	4,59	2.7	50.1
	C	100-119	8,2	0,01	5,26	4,36	1,0	33,1
	C	119-129	7,6	0,01	3,11	4,09	traces	11,7

Notes: Original soil, № A-13; 1.Virgin, № R-1; 2.*Secále cereále → Zéa mays,* № A-1; 3.*Medicágo,* № A-10;; 4.*Zéa mays,* № A-8; 5.*Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max+ Sorghum + Ama-ránthus→Hórde-um+Vicia sativa,* № A-12; 6. *Hórdeum,* № A-6

It has been established that the reaction of the medium in all variants of the upper horizons is weakly alkaline (pHwater - 8.0-8.1), and in the lower ones - upon transition to the carbonate horizons - alkaline (pHwater - 9.0-9.1), which corresponds to irrigated gray-brown soils of Azerbaijan [13]. Over a twenty-year period of permanent cultivation of *Hórdeum*, the humus content in the A' layer was –1.60%, in the A"–1.19%, which is due to an increase in the mineralization of organic matter and a lack of plant material. In the variant of obtaining 3 harvests of green mass per year per hectare, the humus content in A' is higher than –2.73%, which is associated with the year-round intake of fresh plant residues of grass mixtures into the soil. The largest amount of absorbed bases with a predominance of calcium cation, mobile phosphorus and exchangeable potassium was noted in the soil also under variant 5. It was noted that the amount of absorbed bases increased with an increase in humus in the soil, which indicates the important role of humus in the formation of an absorption complex in the upper soil horizons. Based on the data obtained according to the international classification of soils of the world (WRB 2015), irrigated gray-brown soils can be classified as Irragric Cambisols (Protocalcic, Clayic).

Gleyic Calcisols and Irragri Gleyic Calcisols (in WRB 2012). Studies have shown that permanent sowing of *Hórdeum* (variant 6) reduces the thickness of the humus horizon of the soil. In all studied variants of the experiment in accordance with the "Classification and diagnostics of soils of the USSR" [12] and FAO 2015 [7] - Gleyic Calcisols and Irragri Gleyic Calcisols - thin, low-humus, which shows the homogeneity of the soil cover of the experimental area.

For the sample, we present a morphological description of the soil profile of section № K-3 (according to WRB 2015) under variant 5. The territory is located in the Experimental Economy of the Institute of Soil Science and Agrochemistry in Ujar (Kura-Araksin lowland), 600 m from the Baku-Kazakh highway, at an altitude of 16 m above sea level, geographical

coordinates - 40030'20.13 "N , 47040'26.14 "E. SU-29 ° C, WC 2, LP -<10^0.

Soil - Irragri Gleyic Calcisols. The parent rocks are deluvial-alluvial loams. AA4M, IB, IF, vegetation: *Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa,* ST, Hp - 0-27 cm.

A' 0-27 7,5YR 5/6, CL, SB + GR, FR, M (2-5mm) and
27 cm C (>5mm), F–0.5-2mm, E, M, M - 15-40%,
*pF 3-2, SC, MO 2-10% and N;

A" 27-56 7,5YR 5/6, CL, SB +CR,F, FR, M (2-5mm) and
29 cm C (>5 мм), F–0.5-2mm, E, M, M – 15-40%,
*pF -2, PM, MO 2-10% and N, C;

A"/B 56-77 7.5 YR 5/3, CL, SB, PD4 , F, M - 15-40%, M (2-
21cm 5 mm) and C (>5mm), F - 0.5-2mm, *pF -2, SC,
ST 10- 25%,N, C, W;

B/C 77-122 2,5 YR 8/7, PD4 , CL, F, CR +SB, F, M (2-5
45 cm mm), F- 0.5-2mm, *pF -2, SC, MO 2-10% and N,
G, İ;

C 122-155 10 YR 6/3, C, PD4, F -2-5%, LU, FM -2-6mm, MO
33 cm 2- 10%, SC, *pF 3-2 .

The morphological description of section № K-3 shows that the thickness of the arable (0-27 cm) horizon is 27 cm.

The profile of this section up to the B/C horizon (77-122 cm) is described by the main tone 7.5YR, and in the B/C horizon (77-122 cm) - in 2.5 YR tone, then - in 10 YR tone [14].

In the morphological description of the soil profiles of other variants of the experiment, the following horizons were established: A' (arable horizon) with a thickness of 22 to 26 cm; A" (subsoil) - from 44 to 54 cm; B - from 63-75 to 76 cm; B/C - from 103 cm to 119 cm and C - from 129 -137 to 152 cm, which corresponded to the statistical parameters of the morphological properties of irrigated meadow-serozem soils of the Kura-Araks lowland.

On virgin soil, these parameters along the soil profile corresponded to 14, 37, 61, 102, 131 cm (Table 2).

The middle of the soil profile for all variants consisted of transitional horizons (from humus to parent rock - B, B C, and C. A significant level of occurrence of carbonates was noted under *Hórdeum* (63 - 103 cm), somewhat lower under *Zéa máys* of spring sowing (74 - 109 cm) and lowered to a depth of 122-155 cm in variant 5.

The root system of Medicágo and grass mixtures (variant 5) intensively used moisture from the layer of 0-54-56 cm and thus slowed down the rising migration of carbonates.

For 20 years, the thickness of the arable horizon (A1) under *Hórdeum* (farm sowing) was 22 cm, under *Medicágo* - 26 cm, and the largest - under variant 5 (27 cm).

This is due to the different depth soil cultivation, depending on the type of intermediate mixed sowing of crops in order to obtain 3 crops per hectare per year, the depth of penetration of the root system of crops and the year-round supply of fresh organic matter.

Table 2: *Agrochemical indicators for the genetic horizons of the morphological profile of meadow-serozem soil.*

Variant	Horizon, см	Power, cm	pH of water	Humus, %	mg-eq/ 100 g of soil		mg / kg soil	
					Ca	Mg	P2O5	K2O
	A'	0-23	7,95	2,39	17,73	6,17	16,0	257.1
	A"	23-51	8,79	1,90	12,37	6,08	15.0	140.1
	B	51-75	8,59	1,05	7,59	5,86	11.4	99.1
	B/C	75-109	8,72	0,26	5,27	6,21	5.3	64.7
	C	109-139	7,99	trace	6,02	6,00	1,7	35,9
1	A	0-14	7,88	2.40	18,83	5,05	27,3	290,2
	A	14-37	7,91	1,85	14,05	6,37	12.8	230,4
	A/B	37-61	7,87	1,15	11,30	6,87	9.2	181,5
	B	61-102	7,86	0,42	7,06	8,20	2.0	119,0
	C	102-131	7,69	0,10	4,67	3,69	trace	44,1
2	A'	0-25	7,82	2.25	19,47	3,34	19,3	291,2
	A"	25-49	8,01	1,83	11,20	4,40	17,6	163,6
	B	49-75	8,10	0,89	7,56	5,80	11,3	109,8
	B/C	75-110	8,91	0,37	5,23	8,05	4,5	52,7
	C	110-141	8,66	0,07	5,00	6,05	2,3	54,7
3	A'	0-26	7,88	2.82	20,32	8,50	29,5	397,5
	A"	26-54	8,22	2,07	17,17	6,00	24.3	200,4
	B	54-76	8,13	1,45	15,72	7,00	17,5	137,3
	B/C	76-119	8,79	0,70	10,00	9,20	7,4	90,5
	C	119-152	8,77	0,23	8,11	4,25	6,2	77,9
4	A'	0-23	8,11	2.13	18,37	2,94	17,3	238.0
	A"	23-45	8,48	1,33	11,04	5,29	16,1	134.0
	B	45-74	8,92	0,80	9,85	4,19	5,2	83,4
	B/C	74-109	7,89	0,23	9,32	5,71	3.0	30.8
	C	109-137	8,69	trace	4,76	7,11	1,7	23,1
5	A'	0-27	7,69	3,00	21,30	9,50	34,00	423,1
	A"	27-56	8,11	2,38	19,21	8,22	24,60	280,1
	B	56-77	8,45	1,54	18,23	7,77	18,3	169,2
	B/C	77-122	8,68	0,74	15,55	9,21	7,8	100,2
	C	122-155	8,73	0,31	9,33	5,87	3,21	47,8
6	A'	0-22	8,00	1.96	17,71	3,36	15,4	209,7
	A"	22-44	8,86	1,44	11,00	5,58	13,1	111,2
	B	44-63	7,91	0,75	8,42	5,62	4,0	76,4
	B/C	63-103	8,26	0,13	7,82	5,75	1.0	24,7
	C	103-129	8,00	0,02	4,87	6,09	trace	14,7
	C	129→	9,00	-	2,01	5,11	-	0,79

Notes: Original soil,№ K-1; 1.Virgin, № M -24; 2.*Secále cereále → Zéa mays,* № K-4; 3.*Medicágo,* № K-6; 4. *Zéa mays,* № K-8; 5.*Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max+ Sorghum + Ama-ránthus→Hórde-um+Vicia sativa,* № K-3; 6. *Hórdeum,* № K-11

The reaction of the medium in all variants of the upper horizons is slightly alkaline (pHwater - 7.82-8.0), and in the lower horizons - during the transition to carbonate horizons - alkaline (pHwater - 8.66 - 9.0), which corresponds to irrigated meadow-serozemic the soils of the Kura-Araks lowland [13].

During the period of permanent cultivation of *Hórdeum,* the humus content in the A' layer of the soil was ‑1.96%, in A"‑1.44%. In the variant *Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa*, the humus content in A' is higher - 3.0%, in A" (subsoil) - 2.38%, which is due to with a year-round supply of fresh root and stubble residues of grass mixtures to the soil. The largest amount of absorbed bases with a predominance of calcium cation was also noted under variant 5 (in A' it was 30.8 mg-eq / 100 g of soil), gradually decreasing along the profile to 15.2 mg-eq / 100 g (in the C horizon of the soil).

In all variants of the soil profile, the supply of mobile phosphorus and potassium decreased from high in A to low in the B/C and C horizons. Between the agrochemical indicators of the experimental variants: the humus content, the amount of absorbed bases, the amount of mobile phosphorus and exchangeable potassium, there are close reliable (tf > tst) correlations (0.79 ± 0.16 ... 0.98 ± 0.06).

Based on the data obtained according to the international classification of soils of the world (WRB 2015), irrigated meadow-sierozem soils can be classified as Irragric Gleyic Calcisols (Calcic, Loamic).

4.Conclusion

1. A Munsell color book was used to describe the color of the soil samples. The color of the profiles of the irrigated gray-brown soil is described by the tones of the Munsell scales - 10YR - 7.5 YR and 2.5

YR. And the color of the profiles of the irrigated meadow-serozem soil is in tones 7.5YR -2.5 YR and 10 YR.

2.Under the influence of long-term various agricultural uses, the following genetic horizons are formed in the profile of irrigated gray-brown and meadow-serozem soils: A1, A2, B, B/C, C.

3. Considering these changes, in accordance with the WRB 2015 system, irrigated gray-brown soils can be classified as Irragric Cambisols (Protocalcic, Clayic), and meadow-serozemic soils - Irragric Gleyic Calcisols (Calcic, Loamic).

5. References

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