RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
56 (6) 2451-2460, 2024
http://doi.org/10.54910/sabrao2024.56.6.26
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

SOIL COVER RESISTANCE TO ANTHROPOGENIC INFLUENCES IN THE ARID SUBTROPICAL ZONE OF AZERBAIJAN

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SUMMARY

The irrigated soil resistance to degradation is vital in its usability. The ordinary gray-brown, gray, and meadow-gray soils reached degradation to a different degree under irrigation conditions. The soils used as pasture are distinct due to erosion. In irrigated soils, the water-resistant aggregates considerably decreased and resistance to erosion reduced. Therefore, the degradation was intensive in gray-brown, meadow-gray, and gray soils. Generally, dividing the soils for resistance to erosion consisted of five groups: a) the lowest resistant — bottom washing rate (0.040 m/sec), b) low erosion resistant — bottom washing rate (0.040–0.050 m/sec), c) moderate bottom — washing rate (0.051–0.075 m/sec), d) high resistant — bottom washing rate (0.075–0.095 m/sec), and e) the highest erosion — resistant bottom flow rate (0.095 m/sec). The division of soils also comprised five groups based on degradation resistance: a) very weakly resistant, irrigation-eroded, saline, and solon solonchak soils, b) soils with varying degrees of weak resistant erosion, fragmented, and poorly developed vegetation, c) moderately resistant, irrigated poorly salinized, and solonetzificated soils with an inclination of 0.050 and more, d) high-resistant soils with more than 2.5 humus, thick, highly erosion-resistant, and weakly salinized soils, and e) the highest-resistant soils, non-salinized soils with weak surface-inclination, density, irrigated, and highly resistant to erosion.

Keywords: Soil degradation, erosion-resistant, bottom-washing rate, degradation resistance, irrigated soils, grouping against erosion and degradation

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: June 29, 2024; Accepted: September 21, 2024.

Citation: Gurbanov EA, Ganiyeva SA, Mehdiyev BG, Dunyamaliyeva NY, Jafarov TI (2024). Soil cover resistance to anthropogenic influences in the arid subtropical zone of Azerbaijan. *SABRAO J. Breed. Genet.* 56(6): 2451-2460. http://doi.org/10.54910/sabrao2024.56.6.26.

Key findings: The research based on efficient land use is crucial. As a result, the study found that soil resistance to natural and anthropogenic influences is low. Based on soil resistance to external influences, the soils ranked from high to low, light gray-brown, meadow-gray, and gray.

INTRODUCTION

Intensification of anthropogenic influence on environment, including soil cover, causes variations in the ecosystem and results in the development of degradation process. The anthropogenic factors, which affect the ecosystem in the arid subtropical zone, are observable in the soil cover (Mamedov, 2005). The research commenced in the different regions of the world, which showed that plowing by turning the crop layer repeatedly for many years using traditional farm machinery equipment, destroyed the natural soil structure. However, the aridity intensification in the arid bio-climate condition caused a fast humus destruction and intensive mineralization of roots and plant remnants, decreasing soil fertility and degradation process (Hasanov, 2006).

The Kura-Araz lowland is one of the oldest agricultural regions of Azerbaijan, and as a result of the anthropogenic effects on natural complexes in those areas, the widespread degradation in these lands has prevailed for thousands of years. The results of long-term studies showed that in the Kura-Araz lowland, the soils used for agricultural crops sustained salinization. Outcomes of the processes disturbed their water, heat, air, and fertility regimes, with the lands subjected to complete degradation. In modern times, the protection of soil cover and water sources in nature, increasing the fertility of agricultural lands, and efficiently using those lands to obtain a stable and high yield are among the urgent issues facing agricultural experts. From the soil research results, approximately 80% of the soil reserves of the Republic of Azerbaijan have incurred natural and anthropogenic degradation to one degree or another (Mikayilov, 2003).

A guaranteed ecologically safe activity of the soil and vegetation system results from the balanced influence of anthropogenic and natural factors. The improper soil irrigation in agricultural areas mainly disturbed the soil cover, with this disturbance primarily occurring due to changes in the morphogenetic properties of the soil, reduction of humus, salinization, and other factors of degradation.

Therefore, degraded soils surfaced under anthropogenic influences and depart the crop rotation. During the plowing and general cultivation, using heavy farm machinery, their repeated movement over and tightening the soil destroys the soil structure, weakening water-conductivity ability and formation of surface flows (Soil Atlas of the Azerbaijan Republic, 2009). The presented investigations sought to determine and group the resistance of irrigated soils to erosion and anthropogenic degradation to protect them from exogenous influences.

MATERIALS AND METHODS

The soil of the Kura-Araz lowland of the Republic of Azerbaijan became the research area. The resistance of gray, meadow-gray, and light gray-brown soils to anthropogenic influences bore probing. The ordinary, light, meadow, and irrigated anthropogenic subtypes of gray-brown soils spread in the valley. Ordinary gray-brown soils were on the edges of the Kura-Araz valley, foothill parts of the Garabagh, Mil, and Shirvan plains, debris cone of the Bolgarchay in the South of Mughan plain, along the Araz, Ganja-Gazach, and Jeyranchol-Ajinohur. These soils have the characteristics of arid field landscape. The soils underwent perfect investigations anthropogenically before separating them as independent soils in the Azerbaijan Republic (Babayev, 1984). Anthropogenically modified soils occupy 52% of the republic zone, and its area approximately covers 4.5 million hectares.

In these soils, the main methods used for studying the erosion resistance were comparative-geographical (Soils’ geographical distribution based on the granulometric composition and humus content of the arable horizon) and comparative-analytical. The scrutiny of soil erosion resistance employed Kuznetsov's method (Gracheva, 2006). In each station, the research defined the coordinates during the study, applying sections, with the samples taken from morphogenetic horizons. The quantity determination of the water-resistant aggregates used the Savinov method, density in a cylinder, specific mass by a pycnometer, and granulometric composition by a pipette method (Hasanov, 2013).

The calculation of the average diameter of water resistant aggregates used the following formula:

$$\bar{d}_{w_1} = \frac{d_1 P_1 + d_2 P_2 + \cdots + d_n P_n}{100}$$

Where: d_n = the average diameter of particles of different sizes, and

P_n = the amount of individual particles in %.

Obtaining surface roughness followed the formula below:

$$\Delta = 0.7\bar{d}_{w_1}$$

Humus detection engaged Tyurin's method, with statistical analyses defined according to Dospekhov (1985).

It was also notable that gray-brown, meadow-gray, and gray soils have the main placement in the valley, with the morphogenetic and diagnostic indicators of these soils provided in Table 1. The ordinary gray-brown soils develop under wormwood-ephemeral-grain plants. Aridity and warmth of the climate primarily contributed in forming deluvial-proluvial loamy rocks in the non-detergent water regime condition. In the soil profile, the rotten-carbonated B and mainly carbonated-loamy C-horizons are apparently visible, successively alternating with each other. The indications that reflect irrigation erosion development appeared especially in the newly irrigated soils of the relatively inclined zones. The humus amount varied from 2.0% to 2.8% on upper horizons, and these soils were highly calcareous. In the South of Mughan, the gray-brown soils were remarkable due to the quantity of carbonates, ranging from 7% to 8%.

Table 1. Main indicators of the research soil.

Average indicators from 140 soil sections	Soils		
	Gray	Meadow-gray	Light gray-brown
Density of humus horizon (cm)	1.60	2.0	1.80
Humus (%) 0-25 cm, 25-50 cm	1.30	1.50	1.44
C_{rk}: C_{fk}	1.0	1.10	1.40
0-25 cm, 25-50 cm	0.60	0.80	1.70
Al$^{!}$:Al$^{!}$ horizon structure	Cloddy, Cloddy-lumpy	Dust-like- cloddy, coarse-grained	Grained and small-nutty, nutty-cloddy
Location depth of ground-waters (m)	3.0-5.0	3.0-3.5	2.5-5.0
Visibility depth of gypsum in profile (cm)	80-100	120-140	90-110
	20-30	30-40	30-50
Granulometric composition	Average and heavy, loamy	Clayey and heavy, loamy	Heavy loamy
Silt fraction (%)	18.00	24.00	43.00
<0.001, 0-25 cm, 25-50 cm	11.00	20.00	35.20
Physical clay (%)	32.4	37.00	52.80
0-25 cm, 25-50 cm	45.00	50.00	55.80
Water-resistant aggregates (%)	32.6	35.0	38.2
>0.25 mm, 0-25 cm, 25-50 cm	23.0	26.0	38.0
Dry residue (%) 0-200 cm	1.50-3.00	0.75-1.06	0.60
Density (g/cm^3) 0-50 cm	1.18-1.59	1.27-1.32	1.09-1.38
Total density (g/cm^3) 0-50 cm	47.0-49.6	50.0-55.0	52.0-57.0

Ordinary gray-brown soils are neutral and weak in alkaline, and the pH rises to the low horizons. The observed soils have heavy granulometric composition and were clayey and loamy (Salayev, 1991). However, the granulometric composition was heavier in the lower parts of the irrigated zones and the relatively inclined areas than the upper parts. These indicators also showed the physical and chemical degradation development in the soils. Humus and biogenic elements on the upper part also differed from the lower part by their minority. Babayev and Gurbanov (2008) reported that in the Mil-Garabagh plains, this type of soils sustained degradation. The said study also composed a degradation map of soil cover in the same zone and analyzed its major causes. By studying the said map, one found that the basic part of the soils bore a degradation process in the same zones.

In the said valley, the light gray-brown soils have a large area compared with ordinary gray-brown soils. These soils occupy more areas in the foothill parts of the Mil-Garabagh, Southern Mughan, Shirvan plain, around Garamaryam plateau, in the low parts of the Mingachevir reservoir, hollows along Araz, Ganja-Gazakh plain, and Jeyranchol-Ajinohur (Ismayilov, 2004). The above-mentioned soils spread under wormwood-ephemeral plants. With the climate aridity, the zone possesses non-detergent water regime conditions. The groundwater input is very weak in forming the soil because of its position located below. However, these soils contain carbonation. A quantity of humus in the sowing layer was 1.76% to 1.80%, and it was less than the humus quantity found on the upper layer of the soils used as a pasture. Salinized species diversity of the light gray-brown soils materialized by chance. Such soils spread in the South of Mughan and in the foothill parts of the Shirvan plain.

Gray (Calcisols) soils occupy the main widespread soil type in the Kura-Araz lowland. Gray soils especially inhabit a broad area in the semidesert zone of Shirvan, Mil, and Mughan plains. The zone where this soil spreads has a sum of the active temperature at 4200 °C–4500 °C. Annually, the rainfall reaches 200–250 mm in spring and autumn, with a possible evaporation of 1100–1200 mm. A greater role of wormwood and wormwood–ephemeral contributes in the washing of these soils. Gray soil formation emerges on alluvial, proluvial-deluvial, and ancient salty deposits of the Caspian Sea.

The morphological structures, compositions, and gray soil characters in the Kura-Araz valley differed from the gray soils in the Middle Asia (Rozanov, 2009). Differentiation occurs in morphological structure depending on the relief. Generally, the soils were distinct with little humus, low absorbing capacity, and highly calcareous. Their density becomes 70–120 cm, and the humus varies by 1.0%–1.5 % on the upper layer. The major part of the humus gathers on the upper part of the soil. However, the carbonates rise downwards. A quantity of quick soluble salt was slight on upper layers of soils in higher areas; although, its increased quantity was evident toward the low layers. Therefore, all the deeply saline gray soils have a different degree of salinization.

Gray soils served as the main winter pastures in the valley. Their cultivation happens under autumn wheat and cotton crops in partial agriculture (Mammadov, 2007). However, incorrect application of the irrigation technology will result in their secondary salinization. These soils quickly degrade due to their resistance to the process as the main reason. Light-gray, anciently irrigated-gray, and primitive-gray subtype soil types spread in the research zone. Irrigated erosion develops to a different degree in the irrigated soils of relatively inclined areas, especially in the South of Mughan, Mil, Shirvan, and Southeastern Shirvan. It also becomes the chief factor for establishing the degradation process.

Meadow-gray soils are dominant in the valley. These soils' formation occurs in an alluvial and sometimes in a depression. The ground and surface waters have a greater role in developing meadow-gray soils. These soils formed in the semi-hydro-morph condition under the influence of these waters. These soils spread in the stripes between the gray-brown and meadow gray-brown soils of the arid fields, and gray soils developed under the arid condition (Krasnov *et al*., 2008).

In the meadow-gray soils, in the plowed layer, the humus ranged from 1.68% to 1.70%; however, it was 3.25% on the upper layer of the pastures. Humus gradually decreases in the low layers and reaches 0.12%–0.27% at the depth of 100 cm. Although, some reasons of humus decrease in sowing arise, its most noticeable loss was due to the development of irrigation erosion. The meadow-gray soils were notable with high calcareous, and the carbonate quantity was higher than 7%. In these soils, the carbonate rises toward downward like the soils of the lowland mentioned before. In soils, the dry residue quantity was more than 0.1%; however, it has a range from 1% to 2.42% in meadow-gray soils used as a non-irrigated pasture (Mamedov, 1989).

The chlorine and sulfate salts also prevail in the salt structure of meadow-gray soils. The calcium and magnesium amount was noticeably higher in salts. The secondary salinization process was very intensive in these soils, and the mistakes carried out in applying the irrigation technology accelerate in the mentioned soils. More than half of meadow-gray soils appeared degraded to a different degree. The gray-cinnamonic soils occupy a larger area in the Northeast of the valley and around the Mingachevir reservoir (Behbudov and Jafarov, 1980; Abduyev, 2012; Aslanov, 2013). These were mostly eroded soils. Likewise, the different species of erosion-surface, ravine, and wind erosion came about. The gray-cinnamonic soils mainly served for pasture, with the major part of winter pastures located in this zone. Non-rational use from pastures accelerates the erosion process, degrading the soils (Kagramanova, 2013).

In the upper non-eroded layers of gray-cinnamonic soils, the humus ranged from 1.67% to 1.78%, it was 1.14% in moderately eroded soils but was not more than 0.67% in strongly eroded soils. The total nitrogen quantity was 0.028%–0.098% in eroded soils, 0.012%–0.042% in moderately eroded, and 0.009% in strongly eroded soils. These soils were also calcareous; however, the dry residue has a range from 0.36% to 0.96%. In gray-cinnamonic soils, the degradation process intensity was more than the previously shown soils. Except the previously stated soils in the Kura-Araz lowland boggy, the meadow-boggy, saline, and irrigated alluvial-meadow soils possess larger areas.

Swampy (Gleysols) soils were interzonally existent in the different parts of the valley, with their formation related to the groundwater. These soils spread in the Shirvan plain of the Kura-Araz valley, Garasu swamp, Mil, Aghgol and around the Sarisulake, Gur-Gur depression in Mughan, around Mahmudchala, and Gizilaghaj gulf (Volobuyev, 1951, 1965). Halophytes, especially cane and licorice, were characteristic for these soils. The humus quantity was more than 5.5%, having these soils slightly used as pastures. Meadow-boggy (Gleysols) soils possess limited area and are interzonal. These soils appear in depression elements of the zone. Humus varied by 3.8%–5.0% on the upper layer, and a little amount of dry residue was visible. These soils were weakly and moderately salinized. However, these soils' fertility was very high, with a very limited use (Mikayilov, 2003).

Generally, among the anthropogenically modified soils, the irrigated gray-brown soils have greater importance. These soils mainly exist in Garabagh, Mil plains, partially in Shirvan, Southern Mughan, and Ganja-Gazakh plains (Khalilov, 2009; Babayev *et al*., 2011). For a long time, because of irrigation, these soils have been cultured in the areas where irrigation sediments cover the surface and performing correct cultivation. In the subtropical zone (anciently irrigated), the one part of irrigated meadow-gray and gray soils has irrigation sediment covering and an accumulative horizon formation with more density. Recently, these soils' degradation was also for the same reasons caused in irrigated gray-meadow soils. Irrigated meadow-gray and meadow soils widely spread in the zones with the semi-desert landscape at the 0–50 m height of the valley. Frequent variation in the water regime was the major characteristic of these soils.

Past research also succeeded in studying the soil resistance to these processes, while investigating a direction of anthropogenic effect in the soils (Gurbanov, 2010). Some studies revealed analogical findings during investigation and assessment of the soil resistance to anthropogenic effects. However, the used indicators and sphere of influence during its definition were notably different (Gracheva, 2006). Therefore, as per information, the soil resistance to this process requires detection while studying the anthropogenic effects.

RESULT AND DISCUSSION

The research has defined the factors affecting the soil resistance to anthropogenic effects and their indicators based on the results (Table 2). The soil's main features of the resistance to the effects were density of humus layer, sum of absorbed cations, tenacity to erosion (bottom washing velocity of flow-m/sec), resistance to defilation, eroding degree, salinization rate, solonetzification degree, and water regime of the soils.

Major factors of soil resistance to erosion

The bottom washing velocity of the flow has determined soil resistance to erosion (Kuznetsov, 1981). In soil resistance to anthropogenic effects, including erosion, the water-resistant aggregates and indicators of its average diameter size possess a decisive role. Therefore, studying water-resistant aggregates composition and defining average diameter are essential. Using the Savinov method helped analyze a quantity of water-resistant aggregates in the soils, with the average diameter calculated. The surface's bumpy protrusion reached measurement based on the average diameter of water-resistant aggregates (Gracheva, 2006). In the irrigated soils in Azerbaijan, the indicator of water-resistant aggregates is very different. The presented research also determined the bumpiness of the stream channel on the slope and average indicators of the water-resistant aggregates' diameter.

This time shows a fixed soil density and its porosity indicators (Table 3). The latest research has determined that mountainous gray-brown and steppe mountainous-brown soils were highly resistant to erosion. These soils spread in low mountainous, upland gray-brown, and steppe mountainous-brown and foothill zone, containing heavy granulometric composition and humus. Steppe mountainous-brown soils lag behind yellow soils for erosion resistance in the Azerbaijan Republic. These soils spread in the low uplands of the Great and Little Caucasus, possess heavy granulometric composition, and their structural composition proved resistant to water-washing influence (Table 3). The mountainous gray-brown soils appeared considerably non-resistant to the erosion compared with steppe mountainous-brown soils. The indicated soils possess various granulometric compositions, with weakly provided humus. Therefore, in the ordinary gray-brown soils, the average diameter of the water-resistant aggregates was 0.42 mm, and the bottom washing velocity was 0.054 m/sec.

In the meadow-gray and meadow-aluvial soils, the average diameter of the water-resistant aggregates ranged from 0.24 to 0.28 mm. The said indicator proves a weakness of their erosion resistance. In the same soils, the bottom washing velocity of the flow was 0.043 m/sec. In gray-cinnamonic and gray soils, the bottom washing velocity of the flow was 0.040 to 0.041 m/sec. The average diameter of the water-resistance aggregates in the gray-cinnamonic soils was 0.23 mm; however, it was 0.26 mm in gray soils. In the gray and gray-cinnamonic soils, the weak provision of humus quantity with the absorbed bases decreases its erosion resistance. Based on perennial research, the soils' classification for erosion-resistance indicators in the arid subtropical zone is as follows:

a. Very-low erosion resistant soils

The said group comprising gray-brown soils, with their indicators shown as above. Humus was not more than 1.0 to 1.5 in the upper layer of gray-cinnamonic soils in the arid subtropical zone, the density on the surface was 1.23 to 1.25 g/cm^3, and the porosity was 52% to 53%. The bottom washing velocity was not more than 0.040 m/sec.

Table 2. Assessment of the indicators of soil cover resistance to degradation.

No.	Indicators	Very weak	Assessment weak	Medium	High	Very high
1	Density of humus layer (cm)	<5	6-15	16-50	51-80	>80
2	Sum of absorbed cations (mg-eq/100 g)	<10	11-20	21-30	31-40	>40
3	Resistance to erosion, bottom washing velocity of flow (m/sec)	<0.040	0.041-0.050	0.051-0.075	0.076-0.095	>0.095
4	Resistance to defilation (m/sec)	<5	6-10	11-20	21-30	>30
5	Eroded degree	Very strong	Strong	Average	Weak	Unwashed
6	Salinization rate, salt quantity (%)	Very strong >2.0	Strong 1-2.0	Average 0.5-1.0	Weak 0.22-0.5	Non-salinized <0.25
7	Solonetzification rate	Very strong	Strong	Average	Weak	Non-solonetzificated
8	Type of water regime	Unwashing	Unwashing	Weak washing	Washing	Washing
9	Surface inclination (with degree)	>20	11-20	5-10	2-5	2>
10	Surface covering of plants (%)	5-15	15-25	25-50	50-85	85
11	Level of soil protective measure system	There is none	Very little	Low	High	Very high
12	Zone fragmentation	Very strong	Strong	Average	High	Very weak

Table 3. Indicators of soil resistance to erosion.

Soil name	Bottom washing velocity of flow (m/sec.)	Average diameter of water-resistant aggregates (mm)	Density of the soil upper layer (g/cm^3)	Special mass of soil upper layer (g/cm^3)	Porosity (%)	Bumpy protrusion (mm)
Steppe mountainous-brown	0.092	1.16	1.12	2.67	58	0.81
Mountainous gray-brown	0.071	0.71	1.19	2.70	55	0.50
Gray-brown	0.054	0.42	1.20	2.66	54	0.30

b. Low erosion resistant soils

Gray, meadow-gray, and meadow-aluvial soils belonged in this group. In the Kura-Araz plain, these soils spread below the ocean level up to the 0-meter horizons. In the same soils, the average of the bottom washing velocity of the flow was 0.040 to 0.050 m/sec. In the upper layer, the humus was 1.5%–2%, and the density was less on the upper layer, with the soils weakly provided with absorbed bases.

c. Average erosion resistant soils

This group includes gay-brown soils with a bottom washing velocity of the flow of 0.051 to 0.075 m/sec. These soils also appeared in the foothill parts of Southern Mughan, Garabagh, Mil, and Shirvan plains.

Table 4. Eroding indicators of soil cover in the Kur-Araz valley (000 hectares).

Plains	Total area	Eroded soils	Rain (downpour) erosion			Irrigation erosion	Defilation (wind erosion)
			Weak	Average	Strong		
Mughan-Salyan massive	871.1	131.2	21.7	11.7	-	36.2	61.6
Shirvan	508.0	116.9	16.0	8.3	8.6	41.5	42.5
Mil	477.9	29.7	1.9	0.6	-	24.5	2.7
Garabagh	241.8	69.8	18.1	3.8	6.7	24.9	16.3
Total on the valley	2098.8	347.6	57.7	24.4	15.3	127.1	123.1

d. High erosion resistant soils

The steppe mountainous-brown soils belonged in this group, with a bottom washing velocity of the flow from 0.075 to 0.095 m/sec. Humus and water-resistant aggregates comprised the majority of their quantity. These were characteristics for foothill and low upland of the Great and Little Caucasus in Azerbaijan. The soils spread in the Kura-Araz lowland.

In the valley, it was also evident that the soils intensively underwent erosion because of the weakness of soil resistant to erosion (Table 4). Although, the relief was mainly plain, with 347,600 hectares of soils in the total zone eroded, where 127,100 hectares were in the irrigation erosion, and 123,100 hectares were in the wind erosion. Around 97,400 hectares of soil area remained for the rain-downpour erosion. Generally, the erosion development was mainly vivid in the Mughan-Salyan massive, and the defilation (wind erosion) was its major part. Soil resistant to defilation gained evaluation by the velocity of gusty wind. Weak winds can also develop the defilation process in the bare and plowed fields. Salinization and solonetzification degrees were notable based on the obtained 55.5% of the total zone in the valley; however, 56.1% of irrigated soils incurred salinization to a different degree. In the Mughan-Salyan plains, the most salinization was 67.3%, while 68.6% in the Shirvan plain.

In the Garabagh plain, the salinized soils were 24.7%. However, these soils in the Mil plain were 42%. In the valley, the 53.8% of salinized soils sustained this process for a week, 29% to a moderate, and 17.2% to a severe degree. The analysis showed that valley soils were dangerous and non-resistant. The 93.7% of groundwater in the irrigated soil cover of the Mughan and Salyan plains emerged at the depth of 1.0 to 1.3 m. In these plains, the distribution of the groundwater for salty degree differed. Therefore, 49% of the territory has waters with mineralization of 1.0 to 3.0, and 35% has mineralized waters higher than 3.0 g/l. Mineralization of groundwater was higher than 3.0 g/l in 63.1% of the Shirvan plain, 49.5% in Mil plain, and 33.8% of Garabagh plain.

In the Garabagh plain, 61% of soils showed solonetzification according to different degrees. Mostly solonetzificated soils in the Mughan-Salyan plain were 70.0%, and the least solonetzificated soils were 46% in the Garabagh plain. Therefore, one can conclude that the soil cover of the valley was weakly resistant to degradation. Soil resistant to technogenic effects considerably revealed an ingredient of resistance to anthropogenic effects. Technogenic influence on landscape was visible by the violation of soil-plant and relief (especially nano- and micro-norms). Intensive assimilation of minerals developed strong degradation of soil and plant cover, which becomes one of the main reasons of soil evolution.

The classification of soil resistant to anthropogenic influences in the Kura-Araz valley took into account the scientific analysis of resistance indicators to erosion, defilation, and mechanical effects. The soil resistance to natural and anthropogenic influences reached five gradations, as follows:

a. The weakest-resistant soils

These soils comprised fully undeveloped, solonetz, and solonchak, thin, stony gray-cinnamon, and gray. Humus layer showed very thin, and its quantity was less. The vegetation, which was exposed to strong erosion, defilation, covers only 5% to 15% of surface. These were slightly used soils like pasture.

b. Weak-resistant soils

Primitive, thin, and middle dense virgin (pasture) and irrigated-gray and meadow-alluvial soils belong to this group of soils, the bottom washing velocity of the flow was 0.040 to 0.049 m/sec, and sustaining the erosion and defilation with a different degree. The 15%–25% covering of the soil surface comprised plants in the pastures that are strongly fragmented, and not using the soil-protective ameliorative measures in the sowing. The weak resistant soils were prevalent in the Southeastern Shirvan, around the Mingachevir reservoir, and in Mughan, Mil, and Shirvan plains.

c. Moderate-resistant soils

Moderately eroded mountainous gray-brown, gray-meadow, and meadow-alluvial soils with 16–50 cm thickness of humus layer spread in the arid subtropical zone consisted this group of soils. Irrigated, weak, and moderately salinized and solonetzificated soils and soils covered by ancient irrigated sediments with a surface slope of no more than 5°–10° belonged to this group. Erosion resistance covers the soils with a bottom washing velocity of 0.051–0.075 m/sec, in pastures the vegetation is up to 25%–50%, and the moderately fragmented areas. The soil-protective measures were slightly beneficial in the sowing. Moderately resistant soils spread in Ganja-Gazakh and in the zones along the Araz, Garabagh, Mil, and South Mughan. The irrigated soils on the left bank of Yukhari Shirvan canal belonged to them.

d. High-resistant soils

According to this classification, the density of humic layer was 51–80 cm, and the absorbed bases sum was 31–40 mg/eq. For erosion-resistance—a bottom washing flow was 0.076–0.095 m/sec; for defilation-resistance—wind velocity reaches 21–30 m/sec. It was also noticeable that erosion-resistance of soils was higher, and these soils have weak salinized, solonetzificated, and nonsalinized washing water regimes. The soil surface covered by plants was 50%–85%, mostly covering the weakly fragmented areas.

e. The highest-resistant soils

This type of soil include arid subtropical zone with the smallest area, mountainous-brown, and relative widespread anthropogenic soils. The irrigated gray-brown and irrigated meadow-gray soils comprised this group and are prevalent in the zones with relative high and debris cones.

The presented research indicated that some features of the landscape, including inclination indicators of surface, were the recognized main factors of resistance to anthropogenic effects. Increased inclination and the intensive formation of the surface flow was the major factor, which causes material accumulation in the weakly inclined areas. However, the surface flow's non-formation had the groundwater quickly approaching the surface, causing the gradation development. Soil cover fragmentation (especially in ravines and dry valleys) and soil-protective measures were applicable during the cultivation, affecting its resistance.

In the development of ravines and surface erosion, the unobserved soils emerged highly resistant to anthropogenic influences. An annual development of the ravines proved higher when it was at one km (reaching 0–0.1 km), average at 0.1–0.3 km, weak at 0.3–0.5 km, and very weak resistant longer than 0.5 km. In agrarian fields, some difficulties materialized during the use of weak-resistant soils. Therefore, additional measures should be functional in using the same soils, with their resistance to degradation requiring restoration (Demichev *et al*., 2024; Kenenbayev *et al*., 2024; Ramazonov and Mutalov, 2024).

CONCLUSIONS

The results determined that soil cover resistance to degradation and erosion was weak in the valley. In the research zone, the major part of the soils sustained degradation degrees. Yielding ability of the same soils weakens. The salinization, solonetzification, and irrigation erosion become active. Therefore, it is vital to fulfill the noted measures during soil use.

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