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MODERN DIAGNOSTICS OF SOIL SUITABLE FOR COTTON CULTIVATION IN THE KARABAKH PLAIN

Vefa Verdiyeva[1]*, Mete Türkoğlu[2], Mahsati Ismayilova[1], Sahila Mammadova[3], Muhammad Masood Tariq[4]

[1] **Department of Soil Science,** Azerbaijan State Agricultural University, Ganja, Azerbaijan
[2]**Department of Forestry, Hunting and Wildlife,** Iğdır University Technical Vocational School, Iğdır, Turkey
[3]**Department of Plant Protection**, Azerbaijan State Agricultural University, Ganja, Azerbaijan
[4]**Center for Advanced Studies in Vaccinology and Biotechnology (CASVAB),** University of Balochistan, Quetta, Pakistan

***Corresponding Author:** Vefa Verdiyeva. E. mail: vefa_675@mail.ru

Abstract
The Karabakh Plain is a region of strategic importance for Azerbaijan's agricultural production. This area is distinguished by its favorable climate conditions, fertile soil types, and proximity to water resources. Cotton cultivation, which plays a significant role in the annual crop rotation, also has a substantial impact on the socio-economic development of the region. The modern diagnostics of the soil suitable for cotton in the Karabakh plain aims to determine the area's favorable potential for cotton farming and to maximize the use of this potential.
The modern diagnostics of soils for cotton cultivation in the Karabakh plain ensures a thorough evaluation of the land and climatic conditions of the area. However, for the efficient use of land resources, it is essential to accurately diagnose and determine the characteristics of the soils.
Every process that takes place in the soil manifests itself in its morphogenetic diagnostics. Without studying the diagnostic indicators of the soil, it is impossible to study its productivity and protect its fertility.This article examines modern diagnostic methods and perspectives for soils suitable for cotton cultivation in the Karabakh plain.
Keywords: *Cotton farming, Degradation, Diagnostic indicator, Erosion, Humus, Lowland, Soil*

INTRODUCTION

As the severity of the global problems facing humanity today has increased, their perception in a new way and finding solutions have also become more complicated. One of these global problems is the ecological situation of the world. It is becoming more and more clear to humanity that as long as the traditional views and methods of using nature that have existed for thousands of years remain, it will not only be impossible to prevent the approaching ecological crisis, but its rapidly increasing destructive effect will also manifest itself in global socio-economic development.

In a period where the demographic situation of the world is becoming increasingly tense, it is crucial to ensure the proper and sustainable use of soil reserves to protect ecological balance and achieve high-quality yield from plants. Soil is an indispensable natural resource in the lives of humans and other living organisms, serving as a vital component of ecosystems.
Global climate change, soil degradation, and the decline in biodiversity have led to the conversion of soils into more valuable natural reserves.

The soils of the dry subtropical zone are currently subjected to degradation processes such as salinization, sodification, irrigation, wind erosion, grazing erosion, compaction, leaching of humus layer, nutrient imbalances, rising groundwater levels, desertification, etc. Each process occurring in the soil manifests itself in its morphogenetic diagnostics. The understanding of soil productivity potential and the preservation of its fertility necessitate the research of its diagnostic indicators. On the other hand, the classification, taxonomy, and nomenclature of soils are closely related to the study of diagnostic indicators (1).

These are modern methods and technologies used to assess the health of the soil, its productivity and suitability. Soil diagnostics play a critical role in ensuring sustainable and productive agriculture. This process also helps to choose the right agrotechnical measures for the protection and optimal use of the soil. The main objective of research is to identify the modern diagnostic indicators of soils prevalent in the dry subtropical area, provide their morphogenetic description, investigate the fertility parameters of soils, find a correlational relationship between the diagnostic indicators of soils and productivity, identify the factors contributing to soil degradation, and map soil research using modern technologies.

Modern soil diagnostics are the basis for effective and sustainable agriculture. This process allows you to more accurately understand the characteristics of the soil and the needs of plants, more correctly apply agrotechnical measures and, consequently, increase productivity (2).

The aim of the research is to contribute to the application of innovative approaches that ensure more efficient use of land resources for agriculture in the region. In addition, the development of sustainable agricultural practices in cotton cultivation in the Karabakh plain is also one of the main objectives (3). The results are significant both scientifically and practically for the development of the agricultural sector in the region.

The main objective of research is to identify the modern diagnostic indicators of soils prevalent in the dry subtropical area, provide their morphogenetic description, investigate the fertility parameters of soils, find a correlational relationship between the diagnostic indicators of soils and productivity, identify the factors contributing to soil degradation, and map soil research using modern technologies (4).

The investigation of anthropogenic degradation resulting from the intensive use of dry subtropical area soils in agriculture (such as winter grazing, cultivation, etc.), as well as natural degradation processes caused by environmental factors (rainfall, wind, salinization, etc.), and combatting these processes are important for preserving and utilizing soils as a natural resource (5).

MATERIALS AND METHODS

Azerbaijan's dry subtropical region's soils beneficial for cotton cultivation have been chosen as the subject of research (6). In order to conduct research aimed at the modern diagnosis of soils beneficial for cotton cultivation in the dry subtropical zone, soil samples and experiments have been placed in characteristic locations selected based on soil-climate conditions in the research area. This area mainly encompasses the Karabakh plain. The research object is primarily used under traditional irrigation conditions. The Kura and Aras rivers, as well as their tributaries, play a key role in the establishment of the irrigation network in the research area (7). Salinization process in the area is one of the main ecological problems, with one of the main reasons being the proximity of groundwater to the surface.

The salinization process in the area is one of the main ecological problems, and one of the primary causes is the proximity of groundwater to the surface. This issue, especially in areas with intensive irrigation, has a significant impact on soil fertility and productivity. The management of water resources, particularly the regulation of groundwater levels and the improvement of irrigation techniques, is essential to mitigate the negative effects of salinization. In addition, monitoring and controlling soil salinity through modern diagnostic tools and methods is crucial for preserving soil health and ensuring sustainable agricultural practices.

In the context of the Karabakh plain, solving these issues through the application of innovative solutions and advanced soil management methods will contribute to increasing cotton productivity and promoting the long-term sustainability of agricultural production in the region (8). The results of this research are expected to provide valuable insights into the sustainable use of land resources and the implementation of efficient agronomic measures.

The Karabakh plain is bordered by the Kura River to the east and the Araz River to the southeast. The area is separated by gentle slopes from the Lesser Caucasus foothills in the west, with horizons of approximately 60 meters and 70-90 meters respectively. The absolute elevation decreases to -11 meters in the eastern part of the Mil Plain (9).

For many years, cotton has been cultivated in the Barda district. The Barda district is situated regarding the diversion of the Tartar river. They are formed on alluvial deposits (figure 1). Therefore, with a gentle slope, its inclination is very weak and directs towards the bed of the Kura River. The sediments deposited here are quite thick, resulting in a significantly high thickness of the humus layer.

The dry and hot climate of the area results in rapid mineralization of organic matter in the soil, and the amount of humus is not very high. The landscape of the area is largely characterized by its predominant dry desert-like features, with significant fragmentation (10). The amount of precipitation varies between 350-450 mm. The average annual temperature is 14.2°C. Hot and dry summers are observed, while winters tend to be mild and humid.

The soils of this experimental area located in the Barda district have been used for agriculture for a long time. In recent years, various crops have been cultivated on these soils for agricultural purposes. It can be said that achieving high yields is not possible, and there are several reasons for this (11).

The irrigation water for the area comes from the Upper Karabakh canal. Hence, the current influence of this water on the soil is not so significant (12).

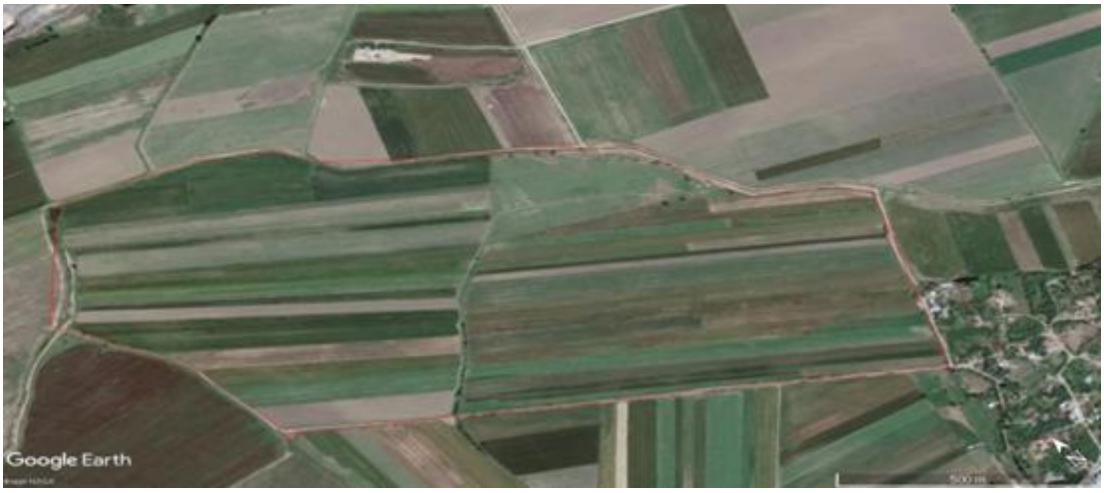

Fig. 1 . Research center's satellite image (Berde district)

The samples taken from the field during the research have been analyzed according to the following methodology (13):

- The mechanical composition of the soil has been analyzed according to the Bouyoucos method.
- Humus content has been analyzed using the Walkey-Black method.
- Total Nitrogen - Kjeldahl Method
- Total phosphorus – Olsen ($NaHCO_3$)
- Total potassium - (AAA the device) Maslovıy ($CHCOONH_4$);
- Exchangeable bases (Ca+Mg) - Titration method (EDTA)"
- Carbonate hardness – Scheibler method
- Total and hygroscopic moisture – drying method
- pH – 1:2,5 soil-water mixture;
- *EC* - 1:2,5 soil-water mixture;

SOIL ANALYSIS METHODS

The Bouyoucos method is a modern and reliable technique specifically designed for precise soil composition analysis. Unlike other methods, this technique allows for the precise analysis of smaller soil particles and enables the results to be obtained with higher accuracy. It provides accurate information about the soil's water retention capacity, fertility, and suitability for agricultural use.

The Walkley-Black method differs from other humus determination methods by being fast and efficient. The main difference is that it indirectly determines the humus content and is based on partial oxidation. This method is widely used, especially for assessing soil fertility, organic matter content, and agricultural potential. However, the limitations of the method and safety precautions must be taken into account.

The Walkley-Black method is one of the most widely used chemical analysis techniques for determining the humus content in soil samples.

The Kjeldahl method is a standard analytical technique used to determine the total nitrogen content in soil and other materials. The distinction of this method lies in its ability to precisely determine specific forms of nitrogen (organic and ammonium nitrogen) and its wide range of applications. However, the method's inability to determine nitrate and nitrite nitrogen, as well as ecological safety concerns, are its main limitations.

This method is indispensable, especially for assessing soil fertility and nitrogen balance in agriculture.

The Olsen method is an effective technique for determining the phosphorus content in alkaline and neutral soils. The main difference of this method is that it determines the amount of phosphorus available for plant uptake, rather than the total phosphorus reserve. This method is an invaluable tool for assessing the fertility of agricultural soils, determining fertilization plans, and monitoring soil health.

The Maslov method and the AAA device, when combined, ensure the precise determination of exchangeable potassium in the soil. This method is an ideal choice for determining soil fertility and fertilization needs. However, the application of additional methods may be required for the analysis of total potassium reserves.

The Exchangeable Bases (Ca+Mg) – Titration Method (EDTA) is used to determine the exchangeable calcium (Ca) and magnesium (Mg) levels in the soil. In this method, soil samples are treated with an EDTA (ethylenediaminetetraacetic acid) solution, which binds to the exchangeable calcium and magnesium ions. The amount of EDTA required to neutralize these ions is then measured through titration, providing a quantitative assessment of the exchangeable calcium and magnesium content in the soil. This method is important for evaluating soil fertility and understanding nutrient availability for plants.

The Scheibler method is an effective technique for the precise and rapid determination of carbonates in soil samples. This method is widely used for assessing the fertility of calcareous soils, determining liming requirements, and analyzing calcareous rocks.

Total and hygroscopic moisture – drying method. The total moisture content determines the amount of all water (both bound and free) in the substance and is measured by the drying method. Hygroscopic moisture refers to the amount of water absorbed by a substance from the surrounding environment. The drying method helps determine the total moisture content by measuring the difference between the initial and dried weight of the substance.

The pH – 1:2.5 Soil-Water Mixture method is a simple yet reliable technique for accurately measuring the pH level of soil. Measuring soil acidity or alkalinity is essential for evaluating nutrient availability for plants and assessing soil fertility. This method is also important for soil optimization and fertilization planning.

The EC – 1:2.5 soil-water mixture method is used to measure the electrical conductivity (EC) of soil. This method involves mixing soil with water in a 1:2.5 ratio and measuring the electrical conductivity of the resulting solution. It helps to assess the salinity level of the soil, which is important for understanding its suitability for agricultural use and its impact on plant growth.

RESULTS AND DISCUSSION

The humus content in the soil is crucial for its fertility. Humus retains nutrients for plants and supports microbial activity. Cotton grows better in soils with high humus content, as it increases the soil's ability to retain water and promotes root development. A low humus level limits cotton yield (14).

In the excavated section in Barda district, the amount of humus in the upper layer is 1.57%, in the subsoil layer; however, it varies slightly and constitutes 1.50%. Under cultivation, the humus content increases relatively at 45-62 cm depth. This is related to the spread of alluvial deposits. In those lands, below 62 cm, the amount of humus sharply decreases to 0.77% and continues in this manner throughout the profile to the end (15).

Soil salinization negatively affects the cotton plant's assimilation of nitrogen in the soil and slows its growth.

Table I. Basic chemical indicators of the characteristic profiles of the research area soils

Location of the profile	Depth (cm)	Humus (%)	Total nitrogen (%)	C:N	CO_2	$CaCO_3$
Barda district, gray-brown soil	0-25	1.6	0.1	4.2	4.9	11.0
	25-46	1.5	0.1	9.4	4.4	10.1
	46-61	1.9	0.1	14.0	5.4	12.3
	61-76	0.8	-	-	-	10.0
	76-89	0.8	-	-	-	12.7
	89-105	0.8	-	-	-	11.1

*N=Nitrogen, C=Carbon, CO_2=Carbob dioxide, $CaCO_3$=Calcium carbonate

Nitrogen is an essential element for the vegetative and generative development of cotton. A nitrogen deficiency causes leaf yellowing and reduces yield. It is possible to prevent the retardation of plant growth by applying nitrogen fertilizer in soils with weak and moderate salinity, however, the application of nitrogen fertilizer in highly salinized soils does not produce any effect. Applying nitrogen fertilizer in salinized soils does not always effectively meet the plants' nitrogen requirements and this also increases the plants' demand for water, thereby increasing evaporation (16).

The relatively low total nitrogen content in irrigated gray-brown soils is related to the genetic characteristics of the soil.. The nitrogen in these soils is one of the key factors, especially for the development of plants. However, the total nitrogen content in these soils is lower due to the natural conditions of the soil. In the gray-brown soils of the Barda region, the further reduction in nitrogen levels is a result of intensive agricultural activities (17). Long-term fertilization and continuous agricultural practices aimed at high productivity disrupt the natural nitrogen balance of the soil, leading to a reduction in its nitrogen reserves. Long-term fertilization and continuous agricultural practices aimed at high productivity disrupt the natural nitrogen balance of the soil, leading to a reduction in its nitrogen reserves (18).

According to the analyses conducted in the Barda region, the amounts of these elements indicate the overall chemical composition of the soil and its productivity potential. For example, the low nitrogen content indicates that this essential element is insufficient in the soil for plant growth. This situation requires proper fertilization and irrigation management for the soil. At the same time, the amounts of elements such as phosphorus and potassium also directly affect the soil's nutrient supply and the development of plant roots.

Table II. The indicators of exchangeable nutrients in cotton soils

The location of the section, the name of the soil	Depth (cm)	Easily hydrolyzable nitrogen (mg/kg)	Exchangeable phosphorus (mg/kg)	Exchangeable potassium (mg/kg)
Barda District, gray grass soils	0-25	123	17,5	740
	25-46	100	17,0	705
	46-61	95	13,0	610
	61-76	"-"	6,6	430
	76-89	"-"	6,6	280

The analysis of macroelement levels also provides important information about the soil's structure, pH level, and overall health. These results help provide well-founded recommendations for improving agricultural practices, optimizing fertilization strategies, and increasing crop yields.

Based on the analysis results, the quantity of macro elements in the Barda district has been illustrated in Fig. 2.

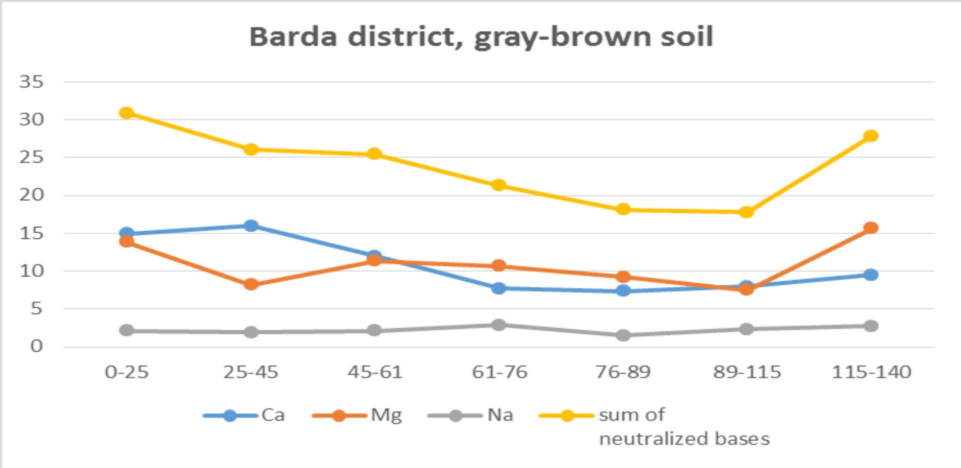

Fig. 2. Distribution of absorbed bases along the profile in typical soils of Barda region

The indicators of pH levels also play a significant role in the fertility indicators of soils. Many natural and anthropogenic factors can influence the level of pH. Especially, soil formation conditions and the hydrometric regime play a significant role in shaping this characteristic (19).

pH, one of the fertility indicators of soils, is an important parameter that indicates the level of acidity or alkalinity of the soil. The pH value of the soil directly affects the bioavailability of essential nutrients for plant growth, meaning it influences how easily plants can absorb them. Additionally, the soil's microbiological activity and the behavior of organisms living within it are also dependent on the pH value. In this regard, the pH indicators of soils provide essential information for increasing crop yields and proper soil management (20).

In cotton-subsoil grey soils, the pH also varies between 8.2 and 8.8. In all sections, similar results have been obtained from research in this direction, or this has been reflected in slightly different figures. In such soils, the cultivation of cotton plants is considered significant (21).

Table III. Morphodiagnostic indicators of cotton soils

Indicators	Irrigated grass-gray soils
Thickness of genetic horizons, in cm.	AYa'zv 20-28 AYa"vca 22-25 A/Bca 30-35 BCAvca 18-25 Ccas 50-60
Structure	Fine granular, cloddy, weakly resistant to the washing effect of water.
Hummus, %	AYa'zv 1.60-2.20 AYa"vca 1.20-1.80 A/Bca 0.85-1.20
Nitrogen, %	AYa'zv 0.15-0.25 AYa"vca 0.09-0.18
$CaCO_3$, %	AYa'zv 8-10 AYa"vca 10-15 A/Bca 12-18
Total absorbed bases, mg/eq.	AYa'zv 16-29 AYa"vca 15-25 A/Bca 12-20
pH in solution	AYa'zv 7.9-8.0 AYa"vca 8.0-8.2
Physical clay, %	AYa'zv 60-80 AYa"vca 70-85
Silt content, %	AYa'zv 25-30 AYa"vca 35-40

CONCLUSION

In the last 20-30 years, the improper use of modern farming techniques in cotton-subsoil soils has led to a sharp decline in their productivity and alteration of their morphological characteristics.

In the Karabakh Plain, it is recommended to use organic matter such as plant residues and green manure to increase the level of humus. During the plowing of cotton-planted soils, it is important to ensure that cotton stalks are chopped and incorporated into the soil. Implementing this process not only helps save on fertilizers but also improves the soil's porosity, regulating its water-air and temperature-air regimes (12). In the soils, the processes of salinization and sodification have reduced the productivity of cultivated agricultural crops, including cotton plants. It has been determined that in the Kura-Araz lowland, the groundwater depth exceeds 1.0 meter in an area of 41,000 hectares (22, 23).

Improving drainage systems and restoring saline soils using chemical methods help enhance soil quality. Leaching of salts and the implementation of crop rotation make cotton cultivation more sustainable. To enhance and optimize the productivity of soils, a crop rotation and successive planting of perennial fodder crops should be established. This method will improve the soil structure-aggregate composition and create favorable optimal soil physical characteristics. These strategies ensure long-term soil fertility, increase cotton production, and contribute to maintaining ecological balance. Thus, sustainable agricultural development in the Karabakh Plain becomes achievable.

Conflict of Interest:

The authors have no conflict of interest.

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