ISSN NO: 2771-8840
November 2025

Morphological and Morphogenetic Characteristics of Dark Gray Soils (in the Example of the Bakhmal District, Jizzakh Region)

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Abstract: This study investigates the morphological and morphogenetic characteristics of dark gray soils developed under natural conditions in the Bakhmal district of the Jizzakh region, Uzbekistan. The research was conducted on uncultivated dryland dark gray soils formed on deluvial–proluvial and loess parent materials within a semi-arid climate and a complex geomorphological setting. Field investigations included the description of soil horizons, determination of humus horizon thickness, and analysis of carbonate accumulation patterns. Laboratory analysis complemented field data to assess the physical structure and textural composition of the profiles.

The results show that the dark gray soils are moderately developed, with a well-structured granular humus horizon, gradual carbonate accumulation, and a clear differentiation among the genetic horizons (A, B, and C). Carbonate concretions were found mainly in the lower horizons, reflecting moderate leaching processes under limited moisture conditions. The morphogenetic features indicate active pedogenic processes influenced by topography and parent material composition. The findings contribute to a better understanding of soil formation mechanisms in Central Uzbekistan and provide valuable data for the regional soil classification and fertility assessment.

Keywords: Dark gray soils; morphogenesis; morphology; Jizzakh region; Bakhmal district; carbonate distribution; loess deposits; dryland soils; genetic horizons; soil profile.

Introduction: The soils of the foothill zones of Central Uzbekistan are diverse in their morphology and genesis due to the complex interplay of relief, parent material, and climatic factors. Among these, the dark gray soils of the Bakhmal district in the Jizzakh region represent a transitional type formed under semi-arid conditions. These soils develop mainly on loess and loess-like deposits under sparse vegetation and are characterized by moderate pedogenesis and carbonate differentiation.

Previous studies (Kuziev et al., 2010; Shadieva et al., 2013) emphasized the importance of understanding the morphogenetic features of gray soils for effective land use and classification. However, the specific morphological variations of dark gray soils across different landscape positions in the Bakhmal district remain insufficiently studied.

Therefore, this study aims to analyze the morphological and morphogenetic characteristics of dark gray soils in relation to relief and slope exposure, to identify the main patterns of pedogenesis and carbonate migration.

Materials and Methods

The study was conducted in the Bakhmal district of the Jizzakh region, within the territory of the Qo‘shchinor farming area. The investigated soils represent dryland dark gray soils formed under natural conditions at altitudes ranging from 1210 to 1250 meters above sea level, in the foothill and piedmont landscapes of the Sangzor basin. The relief is moderately dissected, with slopes ranging between 3° and 10°. The soils have developed mainly on loess and loess-like deposits, and the study sites have remained in their natural state without cultivation.

Field investigations were carried out on three representative soil profiles (Nos. 6, 10, and 18), located in different parts of the landscape: the upper interfluve (Profile 6), the mid-slope with southern exposure (Profile 18), and the mid-slope with northern exposure (Profile 10).

For each profile, detailed morphological descriptions were recorded, including horizon color, texture, structure, density, moisture condition, root distribution, the presence of biogenic traces (insect channels,

ISSN NO: 2771-8840
November 2025

burrows), and the occurrence and form of carbonates. All observations were documented directly in field notebooks following standard soil description procedures recommended by the FAO (2014).

The vertical differentiation of soil horizons — such as changes in color, structure, compactness, and carbonate accumulation — was used to identify morphogenetic characteristics and to determine horizon boundaries. The obtained field data were analyzed comparatively to assess the morphological features and morphogenetic development patterns of the dark gray soils and to establish their relationship with local relief, parent material, and slope exposure.

Results and Discussion

The dark gray soils of the Bakhmal district, Jizzakh region, exhibit distinct morphological and morphogenetic features determined by relief, slope exposure, and parent material. Three representative soil profiles (Nos. 6, 10, and 18) were studied to reveal the structural and genetic differentiation of horizons, as illustrated in Figure 1.

Figure 1. *Comparative morphological features of dark gray soils in the Bakhmal district (Interfluve, Southern, and Northern exposures).*

Profile No. 6 – Upper Interfluve (1252 m a.s.l.)

This profile represents the upper flat part of the landscape, developed on loess-like parent materials under natural conditions.

A (0–10 cm): dark gray, medium loam, granular, friable, rich in fine roots and biogenic traces.

A_1 (10–28 cm): slightly lighter gray, loamy, weakly compacted, fine granular structure.

B_1 (28–52 cm): gray-brown, loamy, weakly structured, with powdery carbonate films on aggregates.

B_2 (52–75 cm): light grayish-brown, loamy, compact, carbonate nodules appear.

C_1 (75–100 cm): light brown, loam, dense, abundant carbonate concretions.

C (100–150 cm): yellowish-brown loess, massive, representing parent material.

The gradual transition of horizons and the depth of carbonate accumulation indicate a stable pedogenesis and moderate leaching under semi-arid conditions.

Profile No. 18 – Mid-Slope, Southern Exposure (1213 m a.s.l.)

A (0–14 cm): dark gray-brown, granular, medium loam, biologically active, with visible root channels.

B_1 (14–45 cm): light gray, medium loam, moderately dense, weak carbonate coatings.

B_2 (45–72 cm): light grayish-brown, loamy, carbonate nodules increase in size and frequency.

C_1 (72–108 cm): brownish-gray, loamy, compact, abundant carbonate concretions.

C (108–160 cm): yellowish-brown loess, massive, dense.

ISSN NO: 2771-8840
November 2025

Carbonate accumulation begins at a depth of 45 cm, which corresponds to intense evaporation and weak downward water movement typical of southern slopes.

Profile No. 10 – Mid-Slope, Northern Exposure (1226 m a.s.l.)

A (0–9 cm): dark gray, heavy loam, granular, rich in humus, many roots and biogenic traces.

A_1 (9–23 cm): gray, heavy loam, fine granular, slightly compact.

B_1 (23–41 cm): light gray, loamy, weakly structured, carbonate flecks appear.

B_2 (41–63 cm): light grayish-brown, moist, loamy, carbonate accumulation increases.

C_1 (63–100 cm): grayish-yellow, dense, numerous carbonate nodules.

C (100–160 cm): yellowish-gray loess, massive, parent material.

The carbonate accumulation starts deeper (at 60 cm) compared to other profiles, which reflects higher soil moisture and leaching under cooler, north-facing slope conditions.

Table 1. Morphogenetic characteristics of dark gray soils under different slope exposures in the Bakhmal district.

№	Soil Type and Description	Landscape Position and Exposure	Slope Degree (°)	Thickness of Humus Horizon (cm)	Surface Horizon Color	Upper Boundary of Carbonates (cm)	Depth of Carbonate Concretions (cm)	Mechanical Composition of A + B_1 + B_2 Horizons
6	Dry dark gray sierozem (uncultivated)	Upper flat part of the slope (watershed)	$0–1^0$	52	Dark gray	52	75	Medium loam
18	Dry dark gray sierozem	Mid-slope (southern exposure)	$3–4^0$	45	Dark gray	45	72	Medium loam
10	Dry dark gray sierozem	Mid-slope (northern exposure)	$4–5^0$	41	Dark grayish tone	41	63	Heavy loam

Comparative analysis reveals that the thickness of the humus horizon varies from 41 to 52 cm, being greatest in the interfluve (Profile 6) and smallest on the northern slope (Profile 10). The upper boundary of carbonates ranges between 45 and 60 cm, depending on exposure and slope position.

Southern slopes show shallow carbonate horizons due to stronger evaporation and limited moisture infiltration, while northern slopes show deeper carbonate accumulation as a result of greater moisture retention.

The mechanical composition is predominantly medium to heavy loam, ensuring moderate water-holding capacity and structural stability. The observed morphological differentiation – granular structure in surface horizons and carbonate concretion formation in subsoil – confirms that these soils are in a stage of moderate pedogenesis, typical of semi-arid climatic conditions.

Conclusion

The dark gray soils of the Bakhmal district in the Jizzakh region are characterized by moderately developed morphogenetic horizons that reflect the combined influence of relief, parent material, and semi-arid climatic conditions.The humus horizon thickness varies from 41 to 52 cm, while the upper carbonate boundary occurs between 45 and 60 cm, depending on slope exposure and landscape position.

Soils on interfluves have deeper and more stable profiles, indicating steady pedogenesis, whereas soils on slopes—especially with southern exposure—exhibit thinner humus layers and shallower carbonate accumulation as a result of stronger evaporation and limited leaching.

ISSN NO: 2771-8840
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The dominance of loamy textures and granular-to-blocky structures indicates moderate moisture retention and active carbonate migration processes. Overall, these dark gray soils represent typical dryland sierozems of the piedmont areas of Central Uzbekistan, serving as a valuable reference for soil classification, land evaluation, and sustainable use in semi-arid agricultural zones.

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