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The influence of grape plantations on morphogenetic diagnostic indicators of arid subtropical soils

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Abstract

Results of the study showed that cultivation of the grey-brown (chestnut) and mountain brown soils under the grape plantation changes their morphogenetic and morphological characteristics in arid subtropical climatic condition. Performed cultivation caused migration of humus into the deeper soil layers. The denser horizon formed under a soft layer. This results in a change of the soil chemical structure and water-physical properties. These changes manifested themselves under irrigative condition.

Key words: *diagnostic index, fertility, grape plants, morphogenetic properties, soil morphology*

INTRODUCTION

Agricultural processes influence soil-forming conditions. Ploughing or growing perennial plants, inter-row deep tillage are the reasons for soil deterioration and mixing its 0–30 cm top layer. Effects of these processes manifest themselves especially under arid climate.

Planting and growing grapes changes soil morphological and morphometric parameters thus affecting soil-forming process. Study of these changes is theoretically and practically significant. These processes, their role and directions are presented in the article.

The study was performed under arid subtropical condition, in Shamkir, Tovuz, Agstafa, Goy-Gol of the Ganja-Gazakh Massif and in Shamkir and Gobustan regions of the upland Shirvan zone. Field studies were carried out in irrigated grey-brown (chestnut) soils of the Ganja-Gazakh Massif and in the cultivated mountain-brown soils from Shirvan Upland. The soils of vineyards planted in different years were used. The studies were performed in soils used as arable lands in order to compare their morphological characteristics.

The study begun by defining zone inclination and boghara. Stationary works and GIS were mainly used in field studies. Some researchers were studying morphological and morphometric properties of the irrigated grey-brown soils and their diagnostic indicators. A characteristic pattern is formed under automorf hydrological condition. Irrigation resulted in the change of hydrological condition and established irrigation hydromorf condition [BABAYEV *et al.* 2006; HASANOV *et al.* 2014; MAMMADOV 2013; URSU, SYNKECICH 1988].

Annual air temperature was 12–13.2°C, and the sum of annual active temperature (>10S) was 4000–4700 in zones covered by grey-brown soils. A frozen layer was observed on the soil surface in some years. Average yearly rainfalls amounted 350–400 mm and moisture coefficient varied by 0.3–0.5. These climatic properties show that the grey-brown soil-forming condition was hydromorf. It is important to say that the soils used under tillage and gardens are irrigated and this also forms irrigation-hydromorf hydrological condition.

Planting and growing under these conditions changed soil morphological and morphometric properties. These soils are of great economic importance.

The second study area was in the low mountainous zone of the Shamakhi and Gobustan districts. Here mountain-brown soils occupy large areas and cultivation is devoid of irrigation.

Deluvial soil-forming process produced clayey-loamy, highly carbonate ($CaCO_3$ = 15–20%) structure, which positively affects grape plant development and especially sugar content of the crop.

Long-term mean annual air temperature was 11.5–12.9°C and the sum of active temperature (>10°C) varied from 3200 to 3500. Long-term mean annual rainfall was 591–636 mm and potential evaporation was 800–900 mm. These natural-ecological conditions produced mountain-brown soils, which are used without irrigation in the middle and low mountain zone of Shirvan Upland and spread over large areas.

At present the agricultural processes affect soil formation and change its direction. Deep ploughing, replacing natural biocoenoses by agrocoenoses, treatment with chemicals and heavy mechanization changed morphogenetic diagnostics of the investigated soils. Some researchers [BABAYEV, JAFAROVA 2006; GURBANOV 2010; HASANOV *et al*. 2014; HUSEYNOV 1972; MAMMADOV 2011; MAMMADOV 2012] confirmed consequences of these changes.

Table 1. Morphogenetic diagnostic parameters of soils

Morphogenetic diagnostics	Soils			
	grey-brown (virgin soils)	irrigated grey-brown (under grape)	mountain brown (virgin soil)	mountain (cultivated)
Thickness of humic horizon, cm	55–60	60–68	54	60
Humic layer colour	brownish	light-brown	dark-brown	brown
Humus structure, % Al′ Al″	granular, small, nut-like	small granular	granular-heap-like, heap-like, nut-like	granular-soft, heap-like small
Granulometric structure	light clayey	medium clayey	clayey	clayey
Silt fraction (>0.001 mm) %	<25–45	26–47	61	64
Physical gley (>0.01 mm) %	50–75	53–78	60–74	62–76
Water-resistant aggregates, % (>0.25 mm)	35–45	28–32	45–50	33–38
Bulk density, $g \cdot m^{-3}$	1.12	1.28	1.06	1.15
Porosity inter-aggregates, %	47	49	52	50
Carbonate layer level	59–63	58–62	60–65	60–65
Density, $g \cdot m^{-3}$	2.66	2.67	2.63	2.63
pH	8.00	8.6	7.0	7.5
Biological activity (0–25 cm)	average	average	average	average
Gypsum horizon, cm	75–80	75–80	97	98

Source: own study.

Trench-ploughing is performed during the establishment of vineyards and 50–60 cm thick horizons mix with each other. The amount of water-resistant aggregates is reduces after such cultivation and humic layer is destroyed.

During the constant cultivations, compacted zone is formed by heavy tractor motion and surface flows are formed after rainfalls. Soil softening around plant roots reduces soil density and increases its porosity. These processes affected soil morphometric diagnostic parameters. A lack of slopes in the Ganja-Gazakh plain is reflected by minimum changes on the soil surface. Signs of hardening are recorded in soil subhorizons. In such soils water permeability weakens considerably.

Irrigation is a measure, which affects soil processes most. Here, uncontrolled water expenditures result in the erosion development, which depends on inclination. Soil leaching is a consequence of this process. Weak erosion does not change soil morphogenetic diagnostic parameters much but when its amount exceeds 2.5–3.0 tons per vegetation season, it affects granulometric structure. This in turn weakens soil resistance to erosion. Prolonged irrigation affects top 50–60 cm soil layer, which is visible in the change of colour hues.

The analyses showed variability of morphogenetic diagnostic parameters in soils under grape plantations and in irrigated soils.

Long cultivation caused the establishment of a dense layer in the irrigated grey-brown and mountain-brown soils and this was distinctly visible in the soil profile. Analyses of chemical and physical properties of soils clearly showed this effect

As already mentioned, the study was performed in two regions in mountain-brown and grey-brown soils. Changes of these soils proceeded in a different form depending on their utilization in agriculture. Soil profiles were taken in unused virgin soils across genetic layers and analysed in order to determine these differences. Erosion of the soil in sampling area was taken into account.

The highest humus content was recorded in the soils of Muganli and Madrasa municipal zones in the

Shamakhi district. Both areas were used under vineyards till 1990. Since 1990 till 2000 the soils were overgrown by grain crops and since 2005 grape plantation was restored. Gentle slopes in the area do not facilitate erosion. Humus content was 5.65% in cultivated soils from the Madrasa municipality and 5.40% in the Muganli municipality. However, humus content in the upper 2–18 cm soil horizon from Agsu was 7.12% and that in 2–20 cm soil profile from Muganly zone amounted 8.27%. The analyses showed that humus content was high in mountain brown soils, which were not used for crops. The least humus content (2.80 to 4.01% in the 0–25 cm soil layer) was found in soils overgrown by winter wheat. There are some reasons of humus depletion in these soils, the main of which are ploughing in summer months and other agrotechnical measures.

The observations showed that some changes appeared in current soil-forming processes. One of the main reasons is utilization of soils under monocultures for a long time period.

Though the study objects are next to each other, possess the same surface relief and climatic condition, they differ in some aspects.

At the beginning of the summer months winter wheat is reaped. The arable area is used as a pasture. The surface cover weakens, the soil is directly heated by sun and all this increases humus mineralization in soil and leads to substantial decrease of its content [Aslanova 2006; Mammadov 2012; 2013].

Nitrogen content changes depending on land use in the mountain-brown soils, For example 2–20 cm layer of a natural virgin soil in the Shamakhy region contained 0.40% N but soil from under grape plantation in the Maraza municipality of Gobustan contained only 0.23% N. Still less nitrogen contain soils from under winter wheat.

The amount of carbonates increases below 50 cm depth in all analysed soils. Sometimes, carbonate layer starts from the depth of 70–80 cm.

The sum of absorbed bases is 30–40 ml·g^{-1} in the upper soil layer and Ca^{++} is the main component.

The study showed that cultivation of grape plants is reflected by the above mentioned soil indices, particularly in the Muganly and Shirvan municipality zones. Obtained results demonstrate that soil fertilisation in vineyards improves soil structure and increases the amount of water resistant aggregates. Other effects include the increase of humus content and the improvement of physical soil properties.

Based on soil indices it is possible to define soil cultivation level. Studied soils presented weak to medium degree of cultivation. In these soils humus, nitrogen and phosphorus resources vary depending on cultivation level.

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Wpływ plantacji winorośli na wskaźniki morfogeniczne gleb subtropikalnych

STRESZCZENIE

Badania wykazały, że w warunkach klimatu subtropikalnego w wyniku zabiegów agrotechnicznych podczas uprawy winorośli na glebach szarobrunatnych oraz brązowych górskich zmieniają się właściwości morfogeniczne i morfologiczne tych gleb.

Prowadzone prace kultywacyjne powodują, że związki humusowe przemieszczają się w głąb profilu glebowego. Poniżej warstwy luźnej powstaje wówczas bardziej zbita warstwa. W wyniku tego zmieniają się wodno-fizyczne właściwości gleb i ich struktura chemiczna. Zmiany te są szczególnie widoczne, gdy plantacje są nawadniane.

Słowa kluczowe: *morfologia gleb, urodzajność, winorośl, właściwości morfogeniczne, wskaźnik diagnostyczny*