Annals of Agrarian Science 15 (2017) 224–234

Contents lists available at ScienceDirect

Annals of Agrarian Science

journal homepage: http://www.journals.elsevier.com/annals-of-agrarian-science

Physical properties of the soils of Georgia

Leo T. Jorbenadze [a], Tengiz F. Urushadze [a, *], Teo T. Urushadze [b], Ilia O. Kunchulia [b]

[a] Agricultural University of Georgia, Micheil Sabashvili Institute of Soil Science, Agrochemistry and Melioration, Georgia
[b] Agricultural University of Georgia, Georgia

ARTICLE INFO

Article history:
Received 12 October 2016
Accepted 15 December 2016
Available online 10 May 2017

Keywords:
Water permeability
Bulk density
Particle density

ABSTRACT

In article is generalized such indexes as water permeability, bulk density, particle density, total porosity, capillary porosity, non-capillary porosity, capillary water capacity, saturation water content, field capacity, permanent wilting point, hydroscopic water content, productive water, pores with air. This indexes were determined in main soils of Georgia: Red (Ferralic Nitisols, Haplic Nitisols), Yellow (Ferric Luvisols), Bog (Dystric Gleysols, Eutric Gleysols, Histosols), Yellow Yellow podzolicic (Stagnic Acrisols, Ferric Acrisols), Yellow brown forest (Stagnic Luvisols, Mollic Luvisols, Humic Luvisols, Ferric Luvisols), Brown forest (Humic Cambisols, Ferric Cambisols, Eutric Cambisols, Dystric Cambisols), Raw carbonate (Rendzic Leptosols), Grey cinnamonic (Calcic Kastanozems, Vertic Kastanozems), Meadow grey cinnamonic (Haplic Kastanozems, Gleyic Kastanozems, Vertic Kastanozems), Cinnamonic (Chromic Cambisols, Calcaric Cambisols, Humic Cambisols, Eutric Cambisols), Meadow cinnamonic (Chromic Cambisols, Calcaric Cambisols, Gleyic Cambisols, Eutric Cambisols), Black (Haplic Vertisols), Chernozems (Voronic Chernozems, Calcaric Chernozems), Mountain meadow (Hyperdistric Umbrisols), Saline soils (Vetric Solonchaks, Mollic Solonetz), Alluvial (Gleyic Fluvisols, Eurtic Fluvisos, Dystric Fluvisols).

Introduction

Georgia is a mountainous country in the Caucasus, neighboring Russia, Azerbaijan, Armenia and Turkey. Georgia is characterized by a great variety of soil types on its small territory, which includes many soils of the world. This can be explained by the enormous variety of soil forming factors within short distances. Therefore, Professor V.V. Dokuchaev, one of the founders of modern soil science in the end of the 19th century, called Georgia an “Open-Air Museum of Soils”.

Soils of Georgia are distinguished by diversity related to mixed character of soil formation. Geological, geomorphologic and climatic conditions change there on comparatively short distances what conditions rich spectrum of soil formation together with diverse vegetation, animal world and surface age.

Soil cover of Georgia has been studied more or less in detail by national as well as foreign researchers. It is important to note that a range of new soil has been outlined (Cinnamonic, Meadow cinnamonic, Yellow brown forest, Brown forest black) later on some of them received world rights of citizenship.

Information about soils of Georgia are sufficiently generalized [1–3]. In this case it is very important to have results about soil physics [4].

Objectives and methods

The objectives of investigation were main soils of Georgia: Red (Ferralic Nitisols, Haplic Nitisols), Yellow (Ferric Luvisols), Bog (Dystric Gleysols, Eutric Gleysols, Histosols), Yellow Yellow podzolicic (Stagnic Acrisols, Ferric Acrisols), Yellow brown forest (Stagnic Luvisols, Mollic Luvisols, Humic Luvisols, Ferric Luvisols), Brown forest (Humic Cambisols, Ferric Cambisols, Eutric Cambisols, Dystric Cambisols), Raw carbonate (Rendzic Leptosols), Grey cinnamonic (Calcic Kastanozems, Vertic Kastanozems), Meadow grey cinnamonic (Haplic Kastanozems, Gleyic Kastanozems, Vertic Kastanozems), Cinnamonic (Chromic Cambisols, Calcaric Cambisols, Humic Cambisols, Eutric Cambisols), Meadow cinnamonic (Chromic Cambisols, Calcaric Cambisols, Gleyic Cambisols, Eutric Cambisols), Black (Haplic Vertisols), Chernozems (Voronic Chernozems, Calcaric Chernozems), Mountain meadow (Hyperdistric Umbrisols), Saline soils (Vetric Solonchaks, Mollic Solonetz),

* Corresponding author.
E-mail address: t_urushadze@yahoo.com (T.F. Urushadze).
Peer review under responsibility of Journal Annals of Agrarian Science.

http://dx.doi.org/10.1016/j.aasci.2017.05.008

Alluvial (Gleyic Fluvisols, Eurtic Fluvisos, Dystric Fluvisols).

The authors generalize such indexes as water permeability, bulk density (g/sm3), particle density (g/sm3), total porosity, capillary porosity, non-capillary porosity, capillary water capacity, saturation water content, saturation water content, field capacity, permanent wilting point, hydroscopic water content, productive water, pores with air.

Physical properties were determined according methods, which often used in country: Water permeability – by method of square, N.A. Kachinskyi [5]; Bulk density by method of auger, N.A. Kachinskyi [5]; Particle density - by pycnometer, N.A. Kachinskyi [5]; Total porosity – by N.A. Kachinskyi [5]; Capillary porosity – by N.A. Kachinskyi [5]; Non-capillary porosity – by N.A. Kachinskyi [5]; Capillary water capacity – by N.A. Kachinskyi [5]; Saturation water content – by Kachinskyi [5]; Field capacity - by A.P. Rozov [5]; Permanent wilting point – by vegetation methods with sprouts, N.A. Kachinskiu [5]; Hydroscopic water content by A.V. Nikolaev [6]; Productive water – by N.A. Kachinskyi [5]; Pores with air – By N.A. Kachinskyi [5].

Results and analysis

Water permeability

Process of water permeability in soil is better to observe at the beginning compared to later stage. This appearance is resulted from soil wetting capacity.

Water permeability in soil profile according to space lowering between aggregates is lowered in most cases from above to down. That is why it is bigger in an accumulation layer that is richer with macro pores (non-capillary pores). In lower parts this pores begin to shorten that results lowering in water permeability.

Water permeability have a major effect on agriculture. With this appearance soil gets water, percolates it distributing in active layer and holds it. This water later is used by plant living processes and is used many biological and chemical processes in soil.

We can conclude that as well as too bad and too intense water permeability have negative effect on soil productivity. For example: Red soils have very low moisture in the upper layers that can be explained by high level of water permeability. Even after heavy rains this soils can be tilled the next day.

According to coefficient of filtration soil is divided into three categories:

1. Water permeability with K > 1 m/day-night
2. Half permeable K = 1–0.00 m/day-night
3. Non permeable K < 0,001 m/day-night

Examination of water permeability in soil have very high practical meaning for irrigation norms and dates. Especially for drip irrigation system to calculate how much water permeability capacity soil have in first one hour. This subject have been examined in Georgia by Refs. [7–43].

In Georgian soils water permeability in 0–20 cm layer (mm/min): Alluvial (594.0) > Mountain meadow (492.0) > Meadow grey cinnamonic (450.0) > Chernozem (420.0) > Cinnamonic (390.0) > Raw carbonate (350.) > Red (336.0) > Black (222.0) > Grey cinnamonic (216.0) > Yellow (168.0) > Meadow cinnamonic (150.0) > Yellow podzolic (105.0) > Brown forest (99.0) > Yellow (90.0) > Saline (39.0) > Bog (8,4).

In 20–50 cm layer (mm/min): Chernozem (840.0) > Red (750.0) > Meadow cinnamonic (462.0) > Cinnamonic (450.0) > Raw carbonate (420.0) > Meadow grey cinnamonic (394.0) > Alluvial (373.0) > Black (262.0) > Mountain meadow (222.0) > Yellow podzolic (162.0) > Yellow brown forest (154.0) > Grey cinnamonic (108.0) > Saline (102.0) > Brown forest (92.0) > Yellow (67.0) > Bog (2,4).

In 50–100 cm layer (mm/min): Cinnamonic (650.0) > Chernozem (615.0) > Raw carbonate (545.0) > Red (336.0) > Meadow grey cinnamonic (280.0) > Meadow cinnamonic (262.0) > Yellow brown forest (154,7) > Alluvial (127.0) > Black (125.0) > Saline (120.0) > Yellow podzolic (114.0) > Mountain meadow (111.0) > Brown forest (84.0) > Grey cinnamonic sodic (57.0) > Yellow (35.0) > Bog (0,42).

In examined 0–20 cm layer water permeability first seven soil types have very good water permeability, next five soil types have good water permeability, next three soil types water permeability is weak but good and the last Bog soil is practically no water permeable, that needs drainage.

In 20–50 cm layer of first eight soil types is very good in water permeability. Next seven types have good water permeability and Bog soil water permeability is practically zero and needs drainage.

In 50–100 cm layer first six soil types have very good water permeability. Next types of soil have good water permeability and Bog soils need drainage.

Bulk density

Soil bulk density (g/cm^3) is an inviolable structure of soil with weight in 1 cm^3 volume. In average, soil bulk density fluctuates between 0,9 and 1,7 (g/cm^3) it is changeable givens and varies upon time periods. In Georgia soil bulk density for different soils have been studied by Refs. [7–74].

Arable, newly tilled soil's bulk density is 1.0–1,1 g/cm^3; if tilled soil is indurated – 1,2–1,3 (g/cm^3); strongly indurated 1,3–1,4 (g/cm^3); in typically indurated case under the ploughing layer bulk density is 1,4–1,6 g/cm^3. Red soils and Yellow podzolic have illuvial horizon bulk density of 1,6–1,8 (g/cm^3).

Soil induration indicates its degradation, that is caused by anthropogenic factors. The main soil types bulk density (g/cm^3) in 0–20 cm layer is (g/cm^3): Yellow podzolic (1,43) > Alluvial (1,21) > Meadow cinnamonic (1,19) > Brown forest (1,15) > Saline (1,14) > Grey cinnamonic (1,13) > Yellow (1,10) > Raw carbonate (1,09) > Meadow grey cinnamonic (1,08) > Cinnamonic (1,07) > Chernozems (1,07) > Yellow brown forest (1,04) > Mountain meadow (1,03) > Black (0,99) > Red (0,92) > Bog (0,91).

In a layer 20–50 cm (g/cm^3): Yellow podzolic (1,43) > Yellow (1,40), Saline (1,40) > Brown forest (1,34) > Yellow brown forest (1,30) > Alluvial (1,27) > Meadow cinnamonic (1,24) > Meadow grey cinnamonic (1,18), Cinnamonic (1,17) > Grey cinnamonic (1,17) > Mountain meadow (1,15) > Raw carbonate (1,12) > Black (1,12) > Chernozem (1,12) > Red (1,07) > Bog (0.9).

In a layer 50–100 cm (g/cm^3): Yellow (1,60) > Brown forest (1,58) > Yellow podzolic (1,47) > Saline (1,45) > Yellow brown forest (1,32) > Alluvial (1,32) > Meadow cinnamonic (1,31) > Chernozem (1,27) > Cinnamonic (1,25) > Black (1,22) > Meadow grey cinnamonic (1,21) > Grey cinnamonic (1,18) > Mountain meadow (1,18) > Raw carbonate (1,16) > Red (1,05) > Bog (0,82).

Thereby 0–20 cm soil layer the highest bulk density has Yellow podzolic (1,43) and the lowest bulk density has got Bog soils (0,91). In the layer of 20–50 cm the highest bulk density of soil has Yellow podzolic (1,43) and the lowest has Bog soils (0,9). A layer of 50–100 cm the highest soil bulk density has Yellow soils (1,43) and the lowest has got Bog soils (0,82).

Among Georgian soil bulk density (g/cm^3) givens can be observed objective laws that soil layers in 0–20 and 20–50 cm is dominating Yellow podzolic and in 50–100 cm layer Yellow and in the lower part of all the soils are Bog soils with the lowest bulk density rate.