



UNIVERSITY OF
Kragujevac



FACULTY OF
AGRONOMY
ČAČAK

SYMBIOTECH

2nd INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY

14-15 March 2024

Faculty of Agronomy in Čačak, University of Kragujevac, Serbia

- PROCEEDINGS -

2nd INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY
XXIX Savetovanje o biotehnologiji sa međunarodnim učešćem

- PROCEEDINGS -

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Print-run: 30

Printed by

MEDIGRAF - Čačak, Aleksandra Savića 42, 32000 Čačak

ISBN 978-86-87611-91-7

Year of publication: 2024

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INFLUENCE OF DIFFERENT SOIL USE ON VERTISOL WATER INFILTRATION

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Abstract: On Vertisol soil type, in the area of Bela Crkva, within the cadastral municipality of Crvena Crkva, research on the impact of different land uses on infiltration rate was conducted in 2021. Infiltration tests were carried out using double metal cylindrical infiltrometers on plots under shrubs, meadows, and cultivated land. It was found that the infiltration rate was highest on the pasture plot compared to the cultivated land and shrubs, which can be attributed to the characteristics of Vertisol and the developed root system that permeates the soil. The obtained results should be taken with caution, considering that the soil is a polydisperse system, and it can contribute to predicting surface runoff, assessing Vertisol waterlogging, and choosing irrigation methods.

Keywords: land use, infiltration capacity, total infiltration

Introduction

In the last few decades, land use/coverage has significantly changed due to climate change and human activities. These changes lead to differences in infiltration characteristics between different land uses/coverages (Jarvis et al., 2013; Reichert et al., 2022).

Infiltration represents the ability of dry soil to absorb and allow water to pass through its surface. Quantitatively, it is expressed as the depth of water that enters the soil over its surface per unit of time. This parameter characterizes the first phase of permeability when free pores in the soil gradually fill with water. It lasts until the soil becomes fully saturated with water. The movement of water through saturated soil under the influence of gravity represents the second phase of permeability or filtration (Gajic B., 2005). Infiltration depends on the total amount of pores in the soil, primarily large pores, cracks, and pedofauna burrows. In the case of an unstable structure, the initial infiltration rapidly decreases due to the breakdown of structural aggregates during their

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wetting and swelling of soil colloids. Wu et al., 2019 and Zhu et al., 2020, state that infiltration decreases with increasing soil bulk density. Regarding organic matter content, studies by individual researchers indicate that infiltration increases with increased organic matter content (Fu et al., 2017; Zhu et al., 2020). However, opposing views are also mentioned, especially in soils with low organic matter content or under drought conditions (Jarvis et al., 2013; Zhu et al., 2020). Knowledge of the size and nature of infiltration is of great importance for agronomic and meliorative soil assessment. The data on this parameter are used to determine surface runoff, irrigation norms, etc. The maximum infiltration rate at which water enters the soil - infiltration capacity, is a dynamic parameter that varies throughout the year depending on the soil profile's permeability, the condition, and characteristics of the soil surface, and the amount of water in it. Therefore, when analyzing registered infiltration test data, deviations can be observed within one location. Generally, soils with high clay content are prone to consolidation, resulting in poor soil structure, low porosity, and high bulk density (Wang et al., 2023; Zhu et al., 2020). The higher the soil moisture content, the lower the infiltration rate. The size of infiltration varies seasonally, and variations also exist from one testing location to another, so it is necessary to perform multiple tests to obtain real data on average infiltration. It also depends on the current condition and previous land use of the plot, as well as the application of agrotechnical measures. Soil cultivation can have a significant impact on infiltration (Cameira et al., 2003). Previous studies (Bormann & Klaassen, 2008; Lopes et al., 2020) have confirmed that infiltration increases after the conversion of intensively used land. Improper human use leads to soil degradation (Bhushan & Yadav, 2000; Gajić et al., 2017). Changing land use, such as clearing natural pastures to increase arable land or replacing degraded arable land due to long-term improper use, inevitably leads to changes in the physical properties and characteristics of pedogenetic processes in the soil. Such land conversion and clearing can disrupt the hydrological balance of the area, increasing the risk of erosion and floods on one hand, and intensifying soil drought, which can result in soil degradation and the absence of expected economic benefits. Water infiltration is a dynamic process that varies over time and space and plays an important role in replenishing soil water reserves, which are crucial for optimal crop growth and development. This study aims to determine the impact of different land uses of the investigated Vertisol site on its infiltration characteristics, predict the characteristics of water movement and dissolved substances in the soil profile, and potentially suggest a choice of irrigation method.

Material and Methods

The study location included the investigation of areas under shrubs (N:529568; E:4973808), grass vegetation - pasture (N:529668; E:4974131), and cultivated land (N:529250; E:4974714) in the area of Bela Crkva within the cadastral municipality of Crvena Crkva.

Fieldwork included sampling soil from the surface horizon using standard sampling methods to a depth of 30 cm in disturbed and undisturbed conditions.

Soil infiltration properties were measured using a double-ring infiltrometer with an inner and outer diameter of 30 cm and 60 cm, respectively, in three repetitions for 200 minutes until a steady infiltration rate was reached.

Sample preparation in disturbed conditions was conducted through the process of drying, grinding, and sieving. Analyses were conducted by applying standard test methods and methods whose source is in professional literature (JDPZ, 1966; JDPZ, 1997). Statistical methods were applied for data processing using Excel.

Results and Discussion

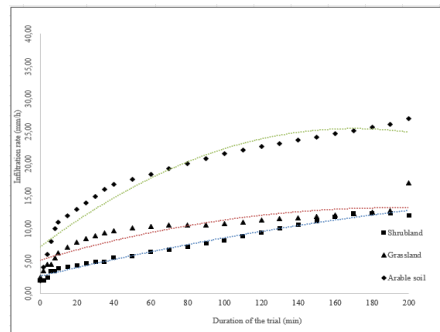
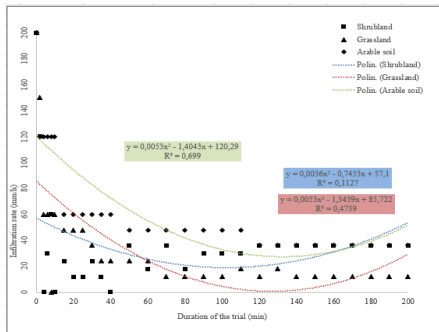
In the area of the cadastral municipality of Crvena Crkva, Vertisols (WRB, 2015) were formed on a loess-like substrate that is composed of light clay, with a slightly lighter mechanical composition compared to typical Vertisols on lake sediments. They are characterized by a very deep humus-rich Avt horizon, thicker than 100 cm, which provides good conditions for plant rooting, water retention, and nutrient availability. However, this type of soil is characterized by unfavorable water-air and thermal regimes due to the unfavorable structure, both in terms of form and size of aggregates, as well as their stability. The aggregate composition changes with changes in moisture conditions - in dry conditions, the soil becomes compact and cracks, while when saturated with water, it softens and swells, with poor water permeability, which negatively affects porosity and aeration. The limitation of this type of soil is reflected in the short interval for cultivation, which is conditioned by the current moisture content. The tested soil samples in the plow (cultivated) horizon, which was also investigated, belong to the light clay (LC) texture class. The values of soil bulk density at the tested sites are slightly lower in the cultivated area compared to the other two sites, while the values of total porosity are higher as a result of changes in land use. The results of the analyzed soil samples are presented in Table 1.

Table 1. Physical and chemical properties of the tested soil samples.

Land usage	Partial density (g/cm ³)	Bulk density (g/cm ³)	Porosity (%)	Humus (%)	Fractions			Texture (IUSS, 2014)
					Total sand (2,00-0,02 mm)	Silt (0,02-0,002)	Clay (<0,002 mm)	
Shrubland	2,71	1,35	50,18	4,48	35,70	28,80	35,50	LC
Grassland	2,70	1,35	50,00	4,05	35,10	29,80	35,10	LC
Arable land	2,76	1,33	51,81	3,47	36,40	28,90	34,70	LC

*LC -Light Clay

In the tested samples, the organic matter content at the Arable soil site is lower compared to the Shrubland and Grassland sites, but still within the range of moderate provision. Figure 1 shows the water infiltration rate curves in the soil. It can be observed that the initial infiltration rate after 2 minutes of measurement was highest in the pasture vegetation plot (150 mm h⁻¹), while in the Shrubland and Arable soil plots, it was 120 mm h⁻¹, which is about 20% lower, likely due to the higher root mass expressed in the pasture site. According to Duiker et al., 2001 and Gajić et al., 2017, when the infiltration rate is higher, runoff is generally lower, which also contributes to soil erosion reduction. The time required to reach a constant infiltration rate differed between plots and varied between 120 minutes for shrubland and arable soil, and 140 minutes for grassland soil.



Graph 1. Average water infiltration rates

Graph 2. Cumulative infiltration

The change in land use had an impact on cumulative infiltration, as shown in Figure 2. Cultivated soil had the highest cumulative infiltration. The difference in initial infiltration and the decrease in infiltration rate over time between the studied treatments indicate a greater ability of the pores in cultivated soil to increase the amount of infiltrated water before filling the

micropores and reaching a steady rate. The presence of plant roots in the pasture area likely contributed to higher water infiltration compared to the cultivated plot.

Conclusion

Based on the investigation of infiltration characteristics of Vertisols under different land uses, it was found that in this type of soil, the presence of a grass cover or a deep root system can increase the infiltration rate. The obtained results should be taken with caution due to the polydisperse nature of the soil. The physical, mechanical, and chemical properties of this type of soil, especially the increased clay content, require agromeliorative measures to avoid the formation of a plow pan that occurs due to constant plowing at the same depth, above which water tends to accumulate during wet periods.

Acknowledgment

Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract No. 451-03-66/2024-03/200011.

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