

AGRO-AMELIORATION

OF YELLOW-EARTH SOILS IN THE IMERETI REGION

AGRO-MEJORA DE SUELOS DE TIERRA AMARILLA EN LA REGIÓN DE IMERETI

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ABSTRACT

The article provides information about the Imereti region of Georgia. With existing yellow flags Research conducted on soils. The aim of the research was the agro-melioration of this type of heavy mechanical composition of soils and the improvement of their physical properties as a result of these measures. The task was to identify and alleviate the factors hindering plant growth and development on yellow earth soils, in the context of agro-landscapes changed by climate change due to global warming. Based on the results of the research, an effective method of conducting agro-ameliorative measures was identified on the experimental site. We selected effective agro-ecological technologies for the yellow-earth soils of the Imereti region of western Georgia. This type of soil of heavy physical and mechanical composition was given the opportunity to be included in agricultural rotation as an agricultural production tool and a reserve agro-economic fund.

Keywords:

Yellow soils, agro-amelioration, climate, agriculture.

RESUMEN

El artículo proporciona información sobre la región de Imereti, Georgia. Se realizó una investigación sobre suelos con indicadores de suelos amarillos. El objetivo de la investigación fue la agromejora de este tipo de suelos de composición mecánica pesada y la mejora de sus propiedades físicas como resultado de estas medidas. El objetivo fue identificar y mitigar los factores que obstaculizan el crecimiento y desarrollo de las plantas en suelos de tierra amarilla, en el contexto de paisajes agrícolas modificados por el cambio climático debido al calentamiento global. Con base en los resultados de la investigación, se identificó un método eficaz para implementar medidas de agromejora en el sitio experimental. Se seleccionaron tecnologías agroecológicas eficaces para los suelos de tierra amarilla de la región de Imereti, en el oeste de Georgia. Este tipo de suelo de composición física y mecánica pesada tuvo la oportunidad de incluirse en la rotación agrícola como herramienta de producción agrícola y fondo agroeconómico de reserva.

Palabras clave:

Suelos amarillos, agromejora, clima, agricultura.

INTRODUCTION

The Imereti region of western Georgia is characterized by extensive areas of yellow-earth soils, which are known for their heavy mechanical composition and limited natural drainage. These physical properties result in challenging conditions for agricultural activities, restricting root development and water movement, and ultimately reducing crop productivity. The increasing pressures of climate change and global warming have further altered the agro-landscapes of the region, exacerbating soil degradation and highlighting the urgent need for sustainable soil management solutions.

Yellow-earth soils, traditionally viewed as marginal or unsuitable for intensive agriculture, represent a significant reserve of untapped agricultural potential if properly managed. Understanding and improving the physical properties of these soils, such as texture, water permeability, and aeration, is critical to enhancing their fertility and supporting healthy plant growth. Effective agro-amelioration strategies that address these limitations can contribute to restoring soil function and integrating these lands into productive agricultural rotations.

The physical properties of soils in Georgia, including those prevalent in the Imereti region, have been extensively studied by Jorbenadze et al. (2017). Their research highlights the challenges posed by heavy mechanical composition and limited permeability in soils such as yellow-earth soils. These characteristics restrict water infiltration and root penetration, which directly affect agricultural productivity. Understanding these physical limitations is essential for designing effective agro-ameliorative interventions that improve soil aeration and drainage, thereby fostering healthier crop development in the Imereti region.

Kvrivishvili et al. (2018), provide a comprehensive overview of Georgian soils in *The Red Book of the soils of Georgia*, emphasizing the importance of soil conservation and sustainable management. They categorize yellow-earth soils as having substantial agricultural potential if managed with appropriate ameliorative techniques. Their work stresses the need to mitigate soil degradation through agro-ecological approaches that restore soil fertility and physical structure. Such sustainable practices align well with the objectives of agro-amelioration in Imereti, particularly in combating the adverse effects of erosion and waterlogging commonly observed in these soils.

In the context of regional agro-ecological conditions, Lortkipanidze (2021), discusses the specific characteristics of dark grey soils in Imereti, providing insights relevant to yellow-earth soils due to their similar physical constraints. The study underscores the role of targeted soil management strategies adapted to local climatic and topographical conditions. Lortkipanidze's findings support the use of integrated agro-ameliorative technologies tailored

to the Imereti region's unique environment, including soil preparation, drainage improvement, and organic matter enrichment to enhance soil productivity.

Seperteladze et al. (2015), contribute valuable knowledge on agro-landscape zoning in western Georgia, emphasizing how precise characterization of natural conditions supports the successful introduction of new crop varieties. Although focused on tangerine cultivation, their research underlines the importance of matching soil and microclimate characteristics with crop requirements. This principle is crucial for agro-amelioration in Imereti's yellow-earth soils, where improved zoning and landscape management can optimize land use and increase agricultural yields despite inherent soil limitations.

Finally, Yigini et al. (2013), extend the European Soil Database to Mediterranean and Caucasus countries, including Georgia, providing a valuable soil resource mapping framework. Their work facilitates the identification of soil types, distribution, and degradation status at a regional scale, serving as a key tool for planning soil conservation and amelioration efforts. For the Imereti region, such spatial information enables targeted interventions on yellow-earth soils, prioritizing areas most vulnerable to degradation and maximizing the efficiency of agro-ameliorative technologies.

In this context, the identification and mitigation of factors hindering crop development on yellow-earth soils is essential for promoting resilient and sustainable farming systems. Implementing tailored agro-ecological technologies not only improves soil health but also helps local farmers adapt to the evolving challenges of climate variability and environmental change.

The study area is located in Dim, Baghdati Municipality. Yellow earth soils are mostly common here. In order to determine the importance of these soils from an agricultural point of view, how useful these soils are for the normal growth and development of certain crops, we focused on field soil research.

After that, we studied the composition and properties of the soil. Based on this, the suitability of these soils for agriculture was determined. We developed ways to utilize yellow earth soils and measures necessary to increase fertility.

Since the research was related to irrigation, drainage, and land reclamation issues, we focused more on the physical properties of the soil: soil capacity, water permeability, mechanical composition, and others.

MATERIALS AND METHODS

The study was conducted in the Dim area, Baghdati Municipality, located in the Imereti region of western Georgia, where yellow-earth soils are predominant. These

soils are characterized by a heavy mechanical composition and limited natural drainage, which pose significant challenges to agricultural productivity. The primary aim of the research was to investigate the agro-amelioration of these soils and to improve their physical properties through targeted interventions.

Field research focused on identifying and alleviating factors that hinder plant growth and development on yellow-earth soils, especially in the context of agro-landscapes altered by climate change and global warming. Stratified soil sampling was performed, examining different horizons down to the bedrock to analyze soil composition, structure, water-holding capacity, permeability, and texture.

Drainage and irrigation conditions were evaluated, considering their critical role in managing soils with heavy physical and mechanical properties. Based on the results, effective agro-ecological technologies and amelioration methods were selected and applied at the experimental site to enhance soil fertility and functionality.

This methodological approach combined traditional soil analysis techniques with practical agro-amelioration measures. The research successfully identified efficient methods for conducting agro-ameliorative interventions that enable yellow-earth soils, previously considered marginal due to their physical constraints, to be integrated into agricultural rotations as valuable production resources and agro-economic reserves.

RESULTS AND DISCUSSION

We made a soil cut in the study area (Figure 1). Since the sampling method depends on the crop that is grown on the plot, and in our case we had mainly perennial crops, we made a trench at a depth of 60 cm and went down to the bedrock. We traced the horizons at 0-20, 20-40 and 40-60 cm. During the survey, it was clear that the waterlogging of these soils was caused by the abundance of groundwater and surface water. When separating the horizons, intense waterlogging was clearly visible throughout the depth of the profile, new orthstein formations were often observed in the illuvial horizon (Figure 2), and here and there a layer of welded orthstein was also present.



Figure 1. Soil cut in the study area.



Figure 2. New orthstein formations.

When describing the horizons, the differentiation of the distribution of iron and micron fractions in the profile was clearly manifested. This content was found in abundance in the illuvial horizon, and less in the upper layer. The clay horizon and the disorder of the water-air regime of these soils ensured the formation of slags, which mostly extended throughout the depth of the profile to the bedrock (Figure 3).

Due to the heavy mechanical composition of the soil, erosion began soon from the arable layer, which ensured the disorder of the water-air regime. During periods of frequent rain, waterlogging processes are common (Figure 4). It is these properties that determined the formation of a suboptimal environment for the normal growth and development of perennial fruit trees, including grapevines and plums, located in the study area, and created conditions that hindered their cultivation. It has become necessary to improve the physical properties of the soil by creating a complex agro-ecological environment.

Our goal is to create optimal conditions for the production of industrially high-quality products in this region, which is complicated by global warming and climate change.

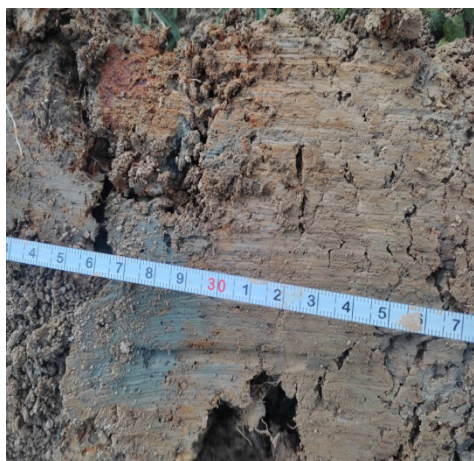


Figure 3. Depth of the profile to the bedrock.



Figure 4. Waterlogging processes.

Our first agro-ameliorative measures include one of the types of drainage melioration - drainage using an open network, which ensures the removal of surface and groundwater from the swampy area. Accordingly, we arranged the permeable and overflow channels in the open (Figure 5). We arranged open trenches in the zoned vineyard in the study area every eighth row, the depth of the trench between the rows was 40 cm, and the main drainage was 60 cm. Since this was the first year of our experiment and we were still in the process of studying the soil, these drainage parameters were not sufficient to completely remove excess moisture from the area. The seedlings on the mentioned plot still had difficulty growing and developing, and developed root rot (Figure 6).

Next year, we increased the number of open trenches, if we had one in every eighth row last year, now we cut it in every fourth and deepened it, so that the depth of the trench would be below the root system of the perennial

plant, so that the drainage system would work perfectly. Accordingly, we increased the depth of the inter-row trenches to 60 cm, and the main drainage to 80 cm. We placed a compacted mass in the open trenches to ensure maximum drainage. After the rains, the result was obvious, we minimized the standing of surface water on the plot.



Figure 5. Permeable and overflowing open-air channels.



Figure 6. Root rot.

In the betel seedlings sector, we had to act differently. Before planting the seedlings, we prepared pits 60 cm deep in advance, first poured medium-sized stones for drainage, then a mixture of peat and fertile forest soil, and planted the betel seedlings so that the betel root system would grow on this mixture. We cut an open trench 2 meters apart on both sides of the seedlings to prevent water from pooling near the roots despite the drainage. We also made the depth of the drainage hole so that it would be below the betel root system. As a result, the betel seedlings did not cause any problems in their growth and development, whereas previously, the normal development of betel seedlings was impossible on these soils.

The second agro-amelioration measure was to improve the physical properties of yellow-clay soils. Due to the heavy mechanical properties of the soil and excess moisture on the mentioned plot, the development of the root system of grape seedlings could not proceed normally. To improve the mechanical condition of the soil, we sowed soybeans, allowed them to reach full maturity, so that the root system could penetrate as deep as possible into the soil, and at the time of harvesting, we cut them and did not dig them up, so that their deeply embedded roots remained in the soil, and after their decay, air ducts remained in place of the roots, and this way the soil would be able to breathe.

Despite the fact that soybeans cannot grow on excessively wet and heavy clay soils, in order to create an optimal environment for the growth and development of soybeans and to maximally develop the rhizosphere, we carried out pre-sowing soil cultivation and preparation before sowing. We mechanically removed weeds 2–3 weeks before sowing, and processed the soil early in spring, loosening it to a depth of 25 cm. Soybeans have the ability to develop a strong root system, extending deep into the lower layers of the soil and feeding on nutrients from those levels. In order to achieve a high yield and good development of soybeans, it was necessary to apply fertilizer to this sector so that the plants had the necessary nutrients and could form a strong root system.

For this purpose, we selected the test preparation Accudo® XTS. This is a biologically based biostimulant, *Bacillus paralicheniformis* (RT1184), extracted from the roots of rice grown in California. It is a natural, non-GMO bacterial strain. The spores colonize the plant roots and over time develop into vegetative cells, strengthening the rhizosphere. *Bacillus paralicheniformis* plays an important role in improving root systems, increasing plant vitality and biomass, and ultimately raising crop yields. It supports seed and tuber sprouting and protects the crop from abiotic stress such as drought or herbicides.

Studies in plant physiology and genetics have shown that these effects are due to the bacterial production and release of hormonal molecules that stimulate plant health and growth. *Bacillus paralicheniformis* (RT1184) helps plants absorb more nutrients from the soil. The stimulant gave soybeans extra energy to develop their root system as much as possible, and by the end of the year, the plants had roots deep enough in the soil. Thus, despite the heavy mechanical nature of yellow-earth soils, we artificially created air ducts that improved the water-air balance of these soils.

In addition to soybeans, we used a mixture of modern preparations, “Numatic” + “Black Magic”, to improve the physical properties of the soil. We irrigated part of the study area with this mixture periodically, four times during the growing season. These two preparations are designed to

improve soils with complex relief characteristics, such as yellow loam soils, which have difficulty absorbing water due to their slopes. “Numatrik” is a mixture of calcium and magnesium along with organic acids, containing 2.4% CaO, 1.1% MgO, and 45.2% organic acids.

Its effect on the soils in the study area included improved water penetration, even distribution of water around the rhizosphere, increased water retention capacity, and higher oxygen content. After applying Numatrik, seedlings planted in the study area developed strong root systems, which in turn affected the quality and yield of the fruit.

“Black Magic” is also a modern preparation that we used in combination with “Numatrik”. This preparation is designed to improve the physical properties of the soil, which it achieves with its specific formulation. It contains calcium, magnesium, nitrogen, humic acids, sugars and microelements. Its specific formulation and regular application to the soil in the heavy mechanical composition soils of our study area, which were characterized by the disorder of the water-air regime, improved aeration and contributed to better drainage.

The soil structure and water retention capacity improved. “Black Magic” contains HPLC sugars, which enhance the microbiological processes occurring in the soil, thus improving the soil quality. The preparation contains wetting and water-retaining agents, which make it possible to moisten dried soils and improve their water retention capacity.

The above-mentioned modern agro-ameliorative measures we have taken have made it possible for the agricultural market to obtain quality products on poor-quality soil. This allows us to maximize the use of land in an already land-poor country. However, we should note that the information provided above is only 2 years old. We think it needs to be continued, it is not final, we continue to test new ideas first and then implement them in practice.

CONCLUSIONS

The study conducted in Dim, Baghdati Municipality, confirmed that yellow earth soils present significant challenges for agriculture due to their heavy mechanical composition, poor water-air regime, and susceptibility to waterlogging. These soil characteristics hindered the healthy development of perennial crops such as grapevines, plums, and betel seedlings.

Initial soil profile analysis revealed severe water retention and orthstein formation throughout the depth, highlighting the need for targeted soil improvement. The application of agro-ameliorative strategies, including open drainage systems, improved planting techniques, and physical soil enhancement using soybeans, proved effective. Soybean cultivation, despite soil limitations, helped to aerate and

condition the soil through decaying root systems, creating channels for improved drainage and root penetration.

Biological soil stimulants such as *Accudo® XTS*, along with modern formulations *Numatrik* and *Black Magic*, enhanced soil structure, moisture distribution, root health, and microbiological activity. These measures significantly improved water infiltration, oxygenation, and nutrient uptake, ultimately leading to better plant vitality and increased crop yields.

Despite these successes, the findings are based on a two-year implementation period. Continued experimentation and long-term monitoring are required to validate the sustainability and broader applicability of these interventions. Nonetheless, the study demonstrates the potential to transform low-fertility, problematic soils into productive agricultural land through a combination of scientific research and innovative soil management practices.

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