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Increasing soil organic matter after application of mineral-organic mixture as an action to prevent climate change

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Introduction

Greenhouse gas (GHG) emissions come mainly from large-area, monoculture agri-food farms that use large amounts of mineral fertilizers and pesticides. On the other hand, deforestation of land for agricultural land and burning of crop residues leads to the release of carbon dioxide (Gorte and Sheikh, 2010; Viglione, 2022). Agricultural activity leads to many changes in the environment, often negative, but on the other hand, it can play an important role in reversing environmental problems by trapping carbon dioxide, increasing water infiltration and preserving rural landscapes and biodiversity (Haverkamp and Marshall, 2009). Thus, it is important to fully explore the relationship between climate change and fertilizer use. Inexpensive, environmentally friendly fertilizer management techniques are desirable in modern agriculture (Erbas and Solakoglu, 2017). The use of zeolite as a fertilizer additive can have a positive effect on both soil properties and the quantity and quality of crops (Jarosz et al. 2022; Mondal et al. 2021). The depletion of soil organic matter directly affects the ecological processes in the soil, therefore the preservation and enrichment of soil organic carbon is crucial to ensure the long-term stability of agricultural and environmental ecosystems. Therefore, the restoration of soil organic matter is a common goal of soil science research (Kim Thi Tran et al. 2015).

The aim of the study

The aim of this study was to investigate the effect of the applied mineral-organic mixtures with the addition of zeolite composites (NaX-Vermiculite - MV and NaX-Carbon - MC) and lignite - L or leonardite - Leo (Figure 1) on the transformation of organic matter in contaminated loamy sand soil. A two-year pot experiment was carried out in a vegetation hall using testing plant – maize (Figure 2). The research compare the changes in soil organic carbon stocks (CS) after the use of innovative fertilizer mixtures.

Figure 1. Schematic representation of the components of fertilizer mixtures

Figure 2. The photos show maize during vegetation

Methods

Table 1. Description of the experimental objects

Object	Mineral salt	Zeolite-vermiculite composite	Zeolite-carbon composite	Lignite	Leonardite
C	-	-	-	-	-
MF	NPK	-	-	-	-
V3% L3%	NPK	3%	-	3%	-
V9% L6%	NPK	9%	-	6%	-
V3% Leo3%	NPK	3%	-	-	3%
V9% Leo6%	NPK	9%	-	-	6%
C3% L3%	NPK	3%	3%	3%	-
C6% L6%	NPK	9%	9%	6%	-
C3% Leo3%	NPK	3%	3%	-	3%
C9% Leo6%	NPK	9%	9%	-	6%

Figure 3. Photos taken during laboratory analyses

The pot experiment consisted of 40 pots, where 8 different fertilization combinations were used and two control objects C-without any fertilizer and MF-fertilized only with mineral salts (Table 1).

In soil samples both after the 1st and 2nd year of research the soil carbon content (SOC) were determined by Tiurin method. On the basis of TOC content (in %) and volumetric density of soil (ρc in Mg m^{-3}), soil carbon stocks (ZC) were calculated after the 1st and after the 2nd year of the experiment (Guo and Gifford, 2002):

ZC = TOC ρc 10 Mg ha^{-1}, where ZC is the soil carbon stock (in Mg C ha^{-1}), TOC is the carbon content (mg C g $soil^{-1}$), ρc is the soil density (bulk density in Mg m^{-3}).

Results and Discussion

Soil organic carbon stocks (ZC) in soil are conditioned by many factors, such as soil properties, cultivation type, fertilization type, climate, irrigation or the type and frequency of agrotechnical operations performed (Garcia-Pausas et al., 2017; Jarosz et al., 2022a). The ZC values (Figure 2) obtained after the 1st year of experiment ranged from 7.45 Mg ha^{-1} in soil with the addition of C3%Leo3% to 9.08 Mg ha^{-1} in the soil with the addition of V9%Leo6%. The results of the research indicate that all the fertilization variants used increased organic carbon stocks after the 2nd year of research, by an average of 16%. The highest increase in ZC content after the 2nd year of research (39%) was determined in the soil with the addition of C3%Leo3%. In general, it can be assumed that the increase in the dose of the mineral-organic mixture increased the organic carbon resources in the soil after the 1st year of research, but the results obtained after the 2nd year of research did not show such a relationship.

Enhancement of soil carbon stocks could contribute to reduction carbon dioxide emissions to the atmosphere. Simultaneous mitigation of the impact on climate change and improvement of soil fertility can result in an increase in good crop quality (World Bank, 2012). Optimization of soil organic carbon stocks brings many benefits. In addition to carbon sequestration, water retention is also increased, soil structure is improved and microbiological and enzymatic activity is supported (Amoah-Antwi et al., 2020). In a study by Zhang et al., (2012), the use of organic additives, compared with mineral fertilization practices, had a beneficial effect on soil carbon sequestration in rice crops, restoring carbon at a rate of 0.20 – 0.88 Mg ha^{-1} $year^{-1}$. However, the increase in the carbon content in the soil was not proportional to the increasing dose of the organic additive. Therefore, the cited authors do not recommend the use of very high doses of organic additives to increase carbon sequestration.

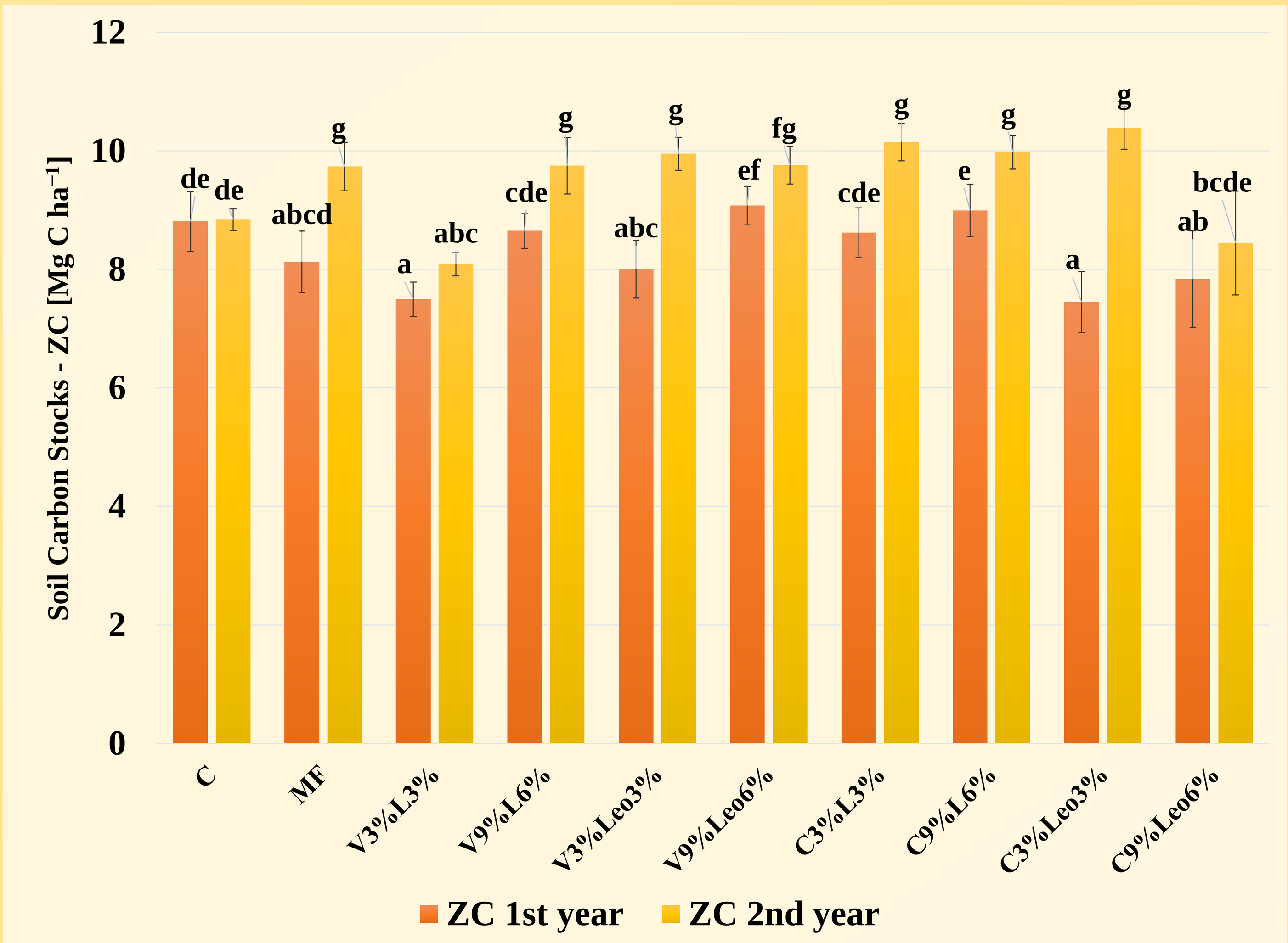

Figure 4. Soil carbon stocks (ZC) in the soil after the 1st and 2nd year of experiment

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