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Unveiling the Potential of Soil Prebiotics: Indigenous Microbial Recruitment for Enhanced Soil Health, Plant Growth, and Carbon Sequestration

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In the context of population growth, climatic change, and environmental concerns, soil management emerge as a pivotal tool for addressing these challenges. To preserve and restore soil fertility and productivity, various innovative agroecological solutions are being explored. Among these, prebiotics stand out as a type of soil biostimulants applied to enhance soil quality, promote plant growth, and potentially improve carbon (C) sequestration. In this aspect, our study was designed to assess and elucidate the effects of two commercial prebiotics, K1® and NUTRIGEO L® (SPK and SPN). The application of these prebiotics, combined with organic wheat straws, resulted in positive effects on both soil fertility and plant growth, surpassing the outcomes of the control (SP). Notably, after 10 weeks of application (D2), these biostimulants led to significant increases in plant biomass, particularly in the roots. This effect is attributed to the enhancement of soil characteristics and the modulation of native microbial communities. With respect to soil characteristics, both prebiotics showed a significant increase in electrical conductivity, cation exchange capacity, and phosphorus availability at D2, while SPN elevated several minerals, such as calcium, boron, and iron. These cationic soil minerals play an important role in the C cycle, sorption of dissolved organic carbon (OC), and organic matter (OM) stability. Regarding soil microbiota, each prebiotic induced a unique shift in the bacterial and, to a greater extent, fungal community structure and diversity, notably at D2. Moreover, we observed the recruitment of a diverse consortium of beneficial native microorganisms (including saprophytic, endophytic, symbiotic, endohyphal, and plant growth promoting taxa) by each prebiotic, contributing to their unique ecological services. For instance, bacteria such as *Caulobacter*, *Sphingobium*, and *Massilia* as well as fungi such as *Mortierella globalpina* and *Schizothecium carpinicola* were identified in SPK. On the other hand, bacteria such as *Chitinophaga*, *Neobacillus*, and *Rhizomicrobium* along with fungi such as *Sordariomycetes* and *Mortierella minutissima* were associated with SPN. These prebiotic treatments, especially SPN, significantly increased plant root mycorrhization and correlated soil proteins (glomalin). The overall effects of the SPN treatment on soil physicochemical and microbial aspects distinguished it with its ability to augment soil OM and total C content, thereby promoting C sequestration. In order to better understand and explain these prebiotics' effects and modes of action, further studies will be conducted to identify and assess their active and passive components and their intricate interactions. These comprehensive findings revealed the potential of prebiotics, shedding light on a novel eco-conscious benefit that can be harnessed through their application: C storage. This newly uncovered service offers a promising tool in the arsenal of climate change mitigation strategies, countering soil exploitation and degradation, the continuous increase in C emissions, and its threatening accumulation in the atmosphere. Our objective is to affirm the pivotal role that prebiotics can play as a new alternative in the agroecological transition towards a modern, resilient, and sustainable agriculture.