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SISTEMAS DE PREPARO E QUALIDADE DO SOLO EM CANA-DE-AÇÚCAR

Botucatu

2022

MARCELA PACOLA OLIVEIRA

SISTEMAS DE PREPARO E QUALIDADE DO SOLO EM CANA-DE-AÇÚCAR

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Aos meus amados pais Roberto e Márcia,

Aos meus irmãos Roberta e Rodrigo,

Que são grandes incentivadores dos meus

estudos

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“A vida não é apenas sobreviver, é fazer a diferença”

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ABSTRACT

The intensification of mechanization in sugarcane cultivation has spurred the development of new technologies to mitigate the effects of soil compaction. Deep strip-till with traffic control has been adopted by the sugar-energy industry as an alternative for improving soil profile. However, few studies have evaluated the effects of deep soil preparation on soil structure and sugarcane yield. The objective of this study was to evaluate the residual effects of liming and soil preparation on soil physical attributes, soil organic matter quality and sugarcane stalk yield after four years of cultivation in a clayey soil. The experiment followed a randomized block design with four treatments and four replicates. The treatments were conventional tillage without liming (CT0), conventional tillage with liming (CT2), modified deep tillage without liming (DT0) and modified deep tillage with liming (DT2). Soil physical attributes, total organic carbon, physical fractionation of organic matter, soil microbial biomass and sugarcane yield were evaluated. Regardless of lime application, deep tillage in the planting band improved the soil porosity to a depth of 0.4 m and decreased the carbon content in the surface layer. Both soil preparation methods improved aggregate stability in the 0.2–0.4 m layer in the absence of liming. Conventional tillage increased the surface soil C content and the mineral-associated C content in deeper layers. Deep tillage with liming increased microorganism activity and decreased compaction throughout the soil profile. Overall, deep tillage with liming improved soil chemical attributes and increased cane yield.

Keywords: *Saccharum spp*; deep strip tillage; traffic control; soil compaction; lime.

RESUMO

Com a intensificação da mecanização das áreas cultivadas com cana-de-açúcar, novas tecnologias para mitigar os efeitos da compactação do solo tem surgido. O preparo profundo canteirizado com controle de tráfego, tem sido adotado pelo setor sucroenergético como alternativa para melhoria do perfil do solo. Entretanto, existem poucos estudos na literatura sobre a eficácia desse sistema na estrutura do solo e produtividade do canavial. Diante disso, objetivou-se avaliar o efeito residual da calagem e sistemas de preparo nos atributos físicos, qualidade da matéria orgânica e produtividade de colmos da cana-de-açúcar após quatro anos de cultivo, em solo com textura argilosa. O delineamento experimental utilizado foi em blocos casualizados, com quatro tratamentos e quatro repetições. Os tratamentos consistiram em: Preparo Convencional sem calcário (CT0), Preparo Convencional com calcário (CT2), Preparo Profundo Modificado sem calcário (DT0) e Preparo Profundo Modificado com calcário (DT2). Foram avaliados os atributos físicos do solo, carbono orgânico total (COT), fracionamento físico da matéria orgânica, biomassa microbiana do solo e produtividade. Observou-se que o preparo profundo independentemente da aplicação do calcário melhorou a porosidade do solo na camada até 0,4 m e diminuiu os teores de carbono na camada superficial. Ambos os preparos sem calagem aumentaram a estabilidade de agregados na camada 0,2-0,4 m. A utilização do preparo convencional aumentou os teores de C em superfície e também os teores de carbono associado a minerais em profundidade. O preparo profundo do solo com aplicação de calcário aumentou a atividade dos microrganismos e diminuiu a compactação em todo perfil. O preparo profundo com calagem melhorou os atributos químicos do solo e aumentou a produtividade de colmos.

Palavras-chave: *Saccharum spp*; preparo profundo em faixa; controle de tráfego; compactação do solo; calcário.

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GENERAL INTRODUCTION

Sugarcane is a semiperennial crop that is harvested annually. Brazil accounts for approximately 30% of global sugarcane production, and it is estimated that approximately 8.24 million hectares are destined for sugar-alcohol activity. The 2020/2021 harvest in Brazil yielded 654.52 million tons, more than half of which was produced in the state of São Paulo (354.28 million tons) (FAOStat 2018; CONAB 2022).

A major problem in sugarcane cultivation is soil compaction by mechanized operations from soil preparation to harvesting, which generate intense, heavy traffic on the soil (ESTEBAN et al., 2019). The machines used to harvest sugarcane cut one row at a time, resulting in heavy traffic in a given area that tends to be greatest near or directly on the planting row. As the size and weight of the agricultural machines involved in these tasks continue to grow, this problem is further aggravated and hinders crop emergence and growth (BOCHTIS et al., 2010; ESTEBAN et al., 2019).

Research has shown that the negative effects of mechanical intervention depend on soil characteristics such as texture, water content, organic matter, soil mobilization/depth of preparation and type of implement used and can include changes in density and soil microporosity (VISCHI - FILHO et al., 2017), macroporosity and total porosity (LANA et al., 2017), and soil resistance to root penetration (DE LIMA et al., 2017). It is essential to develop practices that minimize damage to soil structure to avoid impairing water and nutrient absorption and sugarcane yield (SOUZA et al., 2014).

One of the most effective strategies to reduce soil compaction is controlled traffic agriculture, which concentrates all of the tire load in a permanent traffic zone (ESTEBAN et al., 2019). Controlled traffic agriculture increases the volume of uncompacted soil for crop development (Galambošová et al., 2017). Guidance systems based on the Global Positioning System (GPS) allow soil preparation and furrowing to be planned and carried out only in predefined locations. This technology prevents ratoon damage due to machine traffic (SOUZA et al., 2014), in addition to providing fuel and energy savings compared with conventional tillage (MARTINS et al., 2021).

Deep tillage in strips was developed to promote the development and maintenance of the most favorable soil structure for root development and infiltration and water storage in a delimited “bed” site. This tillage system mobilizes the soil in a localized way using implements that simultaneously perform deep subsoiling, break clods, apply and incorporate amendments and windrow the straw (MARASCA et al., 2015; SCARPARE et al., 2019a). The effects of soil preparation on the physical structure of soil and yield depend on complex mechanisms that are sensitive to equipment type(s), traffic intensity, soil moisture conditions at the time of preparation, and management of plant residues, among other factors (KUMAR; SAINI; BHATNAGAR, 2012; MARASCA et al., 2015; SCARPARE et al., 2019a).

Furthermore, in mechanized harvesting systems, straw is left on the soil surface. Straw maintenance and decomposition directly affect the quantity, quality and lability of soil organic matter (SOM) and favor increases in total organic carbon (TOC) content in the surface layers (LOSS et al., 2011). TOC and SOM are very sensitive to disturbances caused by soil management (CORREIA; ALLEONI, 2011). Some components of SOM are indicators of its quality, such as labile carbon, light-fraction carbon and particulate organic matter carbon (POC) resulting from different particle size fractions (TORRES et al., 2015). Physical fractioning of SOM enables the quantification of not only POC but also mineral-associated organic carbon (MOC), which is useful for identifying changes arising from soil management practices (CAMBARDELLA; ELLIOT, 1992; TORRES et al., 2015).

Other indicators of soil quality include the microbiological properties of the soil, such as microbial biomass and metabolic activity (SANTONI et al., 2022). Microorganisms play a key role in maintaining soil quality by performing many essential functions, such as nutrient cycling, SOM renewal, nutrient mobilization and immobilization and soil structure maintenance (SANTONI et al., 2022; XUE; YAO; HUANG, 2006). Any change in the soil can directly affect soil microbial activity and abundance, leading to changes in biochemical processes, plant growth and development and soil fertility (DA SILVA et al., 2012; MUNIER-LAMY; BORDE, 2000).

For sugarcane cultivation, soil preparation is not limited to operations that impact the physical structure of the soil but also includes management of soil chemical properties to provide an ideal environment for sugarcane development.

Liming is particularly relevant, as it neutralizes toxic Al^{3+} , provides Ca^{2+} and Mg^{2+} , increases pH and improves soil physical and chemical attributes, resulting in better yields (ROSSETTO et al., 2004; SCARPARE et al., 2019a; ZANDONÁ et al., 2015). Liming also physically (MUNNER; OADES, 1989) and chemically (PAUL; CLARK, 1989) protects SOM from decomposition.

Liming recommendations for sugarcane were developed for use in conventional tillage systems. Research has not fully addressed the impact of new soil preparation practices on acidity correction. Raji (2008) evaluated the application of lime to sugarcane and concluded that the official recommendations for liming by Spironello et al. (1997) are underestimates for current cropping systems.

The present research hypothesized that deep tillage and concentrated lime application improve soil physical attributes, organic matter quality and microbial activity and provide favorable conditions for root development, thereby increasing stalk yield. In addition, the residual effect of liming under deep tillage is expected to correct soil acidity at greater depths than under conventional tillage, which promotes a correction gradient. Therefore, the objective of this work was to evaluate sugarcane performance and soil physical attributes, organic matter quality, microbial activity and C stocks as a function of conventional or deep tillage with and without liming.

FINAL CONSIDERATIONS

The present study provides a better understanding of the long-term effects of combining conventional or deep tillage with liming on different soil parameters. Localized lime application under deep tillage improved fertility parameters to a depth of 1 m. Furthermore, this treatment alleviated soil compaction in the long-term but decreased the soil organic carbon content on the surface. In general, the physical parameters of the soil varied depending on the tillage system and lime application, and the best results were obtained under deep tillage. Deep tillage also increased soil microbial activity and, in turn, nutrient mineralization for sugarcane crop uptake. Liming increased stalk and sugar yields, and these effects were greater under localized lime application. These results support the promising potential of this new soil management system, but further studies of different locations, soil textural classes and other system aspects are needed for full validation.

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