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Evaluation of the effects of deep tillage and organic amendments on soil characteristics and sunflower and okra yield across successive seasons

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Abstract

Clay soils in arid and semi-arid environments are highly prone to compaction and hardpan formation, posing significant risks such as desertification and soil degradation, which significantly impede root growth and limit crop productivity. A trial experiment was executed over two consecutive seasons at the College of Agriculture, University of Basrah, to assess the impact of deep tillage and soil organic amendments (cow manure) on the physical properties of the field soil and crop production. In the first season (S_1), the field was divided into two parts, with the local variety of sunflower (Ishaqi1) planted in one part and the other part remaining unplanted. In the second season (S_2), the entire field was planted with the local variety of okra (Petra). Six treatment combinations were involved in this study, obtained from both seasons. The treatment ($FUPS_{1,2}$) significantly decreased the bulk density and soil penetration resistance while increasing the total porosity. FS_1 produced the highest saturated hydraulic conductivity of (0.594 m day^{-1}). The highest sunflower grain yield, 703.33 g m^{-2}, was obtained under the FS_1 treatment, showing a significant increase compared to the UFS_1 treatment, 508.67 g m^{-2}, during the first season. The $FUPS_{1,2}$ and $FPS_{1,2}$ improved okra yield, recording 1044.09 and 979.94 g plant^{-1}, respectively. These results suggest that the combination of deep tillage, manure, and optimal crop rotation improves the soil's physical properties and enhances the productivity of successive crops. This study demonstrates the feasible benefits of combine tillage machine into agricultural cropping systems for growing multiple crops.

Keywords: Bulk density, deep tillage, hydraulic conductivity, manure, penetration resistance, yield

Introduction

Climate change, rising temperatures, land degradation, and soil erosion aggravate desertification and soil quality deterioration, posing crucial environmental risks to agronomic productivity and ecosystem resilience in arid and semi-arid regions. These adverse factors are most evident in clay soils, which tend to form compacted layers or hardpans that severely hinder growth rate and root proliferation. (Jakobs *et al.,* 2019; El Mekkaoui *et al.,* 2023; Zhang *et al.,* 2024). From this perspective, the appraisal of deep tillage and organic amendments on soil profile and yield of the cropping system represented by sunflower and okra across successive seasons proposes a timely and objective avenue to alleviate these threats, through ameliorating soil characteristics and boosting plant yield under progressively stressed agricultural ecosystems.

Tillage process is one of the main agronomic practices for soil preparation and creates appropriate seedbed conditions by conducting some operations such as breaking up and smoothing the soil clumps. These procedures can improve both the bulk density and resistance to penetration of the soil and increase the ability of the soil to retain moisture, as tillage increases the volume of loose soil, thereby improving the physicochemical properties of the soil (Salar *et al.,* 2013; Xue *et al.,* 2018; Zhang *et al.,* 2023).

Hardpan layers are formed due to compaction of heavy agricultural equipment, particularly under high soil moisture; hence, these hard layers increase, especially when tillage treatments are repeated at constant depths. Moreover, the presence of hard layers negatively affects many soil properties and plant growth, such as high bulk density, prevalence of anaerobic conditions, lack of oxygen necessary for root cell division, increased soil resistance to root penetration, and lack of microbial activity in the soil, resulting in poor plant development and stunted root

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