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RESEARCH ARTICLE

Employment of GIS techniques to assess the long-term impact of tillage on the soil organic carbon of agricultural fields under hyper-arid conditions

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Abstract

A study on six 50 ha agricultural fields was conducted to investigate the effect of conservation tillage practices on the long-term (1990–2016) changes in the soil organic carbon (SOC) content of the topsoil layers (0–10 cm) of agricultural fields. The experimental fields were selected from the 49 fields of the Tawdeehiya Arable Farm (TAF), located 200 kilometers southeast of Riyadh, the capital city of the Kingdom of Saudi Arabia. Data sets from laboratory determined SOC and the corresponding Landsat images generated vegetation indices, namely, the Normalized Difference Vegetation Index (NDVI) and the Bare Soil Index (BSI), were utilized for the prediction of SOC using multivariate regression techniques. Long-term changes in the SOC content of the experimental fields, as a result of different tillage practices, were also studied. The developed SOC prediction models exhibited high accuracy indicated by R^2 values ranging from 0.73 to 0.85, RMSE values of 0.34 to 0.85 g kg^{-1} and P-values of less than 0.0001. The cross-validation results (R^2 of 0.61–0.70, RMSE value of 0.34–0.85 g kg^{-1} and P-values of less than 0.0001) confirmed the high accuracy of the developed SOC prediction models. Results also revealed that the change in the SOC content was clearly associated with soil tillage practices. On the average, 76% of the all agricultural fields in the experimental farm showed a decrease of up to 24 g kg^{-1} in their SOC content after 10 years (1990–2000) of continuous conventional tillage practices. On the other hand, an average increase of up to 37 g kg^{-1} in the SOC content was observed in 88% of the studied fields at the end of the study period (2016), where conservation tillage was a continous and consistent practice in the experimental farm.

Introduction

Soil organic matter (SOM) plays an important role in the stabilization of soil structure, retention and release of plant nutrients, infiltration and storage of water in the soil; therefore, it is an essential element for soil health and fertility and food production [1]. The soil organic