

Effect of Cropping Sequences on Soil Biological Activity in Semiarid Region of Western Canada

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Abstract

Soil productivity and environmental sustainability hinge on the physical, chemical and biological properties of the soil. Soil dehydrogenases (DHs) are one of the major classes of intracellular oxidoreductase enzymes involved in energy metabolism of living cells. The soil DHs activity is used as an indicator of overall soil microbial activity.

This study employed the soil DHs assay to examine the effect of different cropping sequences including wheat, mustard and pulse crops in 4-year rotation on the soil biological activity. The DHs assay used in this study was originally developed by Le Casida et al. (1964). In this method, triphenyltetrazolium chloride (TTC) is used as an indicator dye that helps to observe electron transport system activity. The DHs involved in electron transport system reduce the colourless soluble TTC (substrate) and convert it into an insoluble red colour product, known as triphenylformazan (TPF). TPF can be quantified by spectrophotometry at the visible wavelength of 485 nm. Higher the intensity of the red colour in the soil extract solution, higher is the concentration of TPF and hence the higher DHs activity. In this study, the results of DHs assay of the final year (2014) of different 4-year crop rotations are presented. The study clearly showed that frequent inclusion of pulse crops especially chickpea in the cropping systems is conducive to the soil biological activity.

Introduction

Soil productivity and environmental sustainability hinge on the physical, chemical and biological properties of the soil. Soil dehydrogenases (DHs) are one of the major classes of intracellular oxidoreductase enzymes involved in energy metabolism of living cells. The soil DHs activity is used as an indicator of overall soil microbial activity.

Objective

The objective of this study is to determine the effect of cropping sequences on soil biological activity. More specifically, to study the effect of different cropping sequences including wheat, mustard and pulse crops in 4-year rotation on the soil biological activity.

Materials & Methods

Location and Duration of the Study

Study was carried out in AAFC Research Station, Swift Current, and Saskatchewan in the period of 2011-2014 for 4-year crop rotation.

Soil Type

Swinton Silt Loam, an Orthic Brown Chernozem Soil with pH at 6.5 was used in this study.

Treatments

Soil samples for DHs assay were taken in July and September in the 2014 crop season from 14 different cropping sequences in 4-year rotation (Figure 1 & 2).

Experimental Design

This study employed the soil DHs assay in laboratory to examine the effect of different cropping sequences including wheat, mustard and pulse crops in 4-year rotation on the soil biological activity with randomized complete block design having 4 replicates and plot size: 4 m x 12 m.

Soil Dehydrogenase Assay

The DHs assay used in this study was originally developed by Le Casida et al. (1964). In this method, triphenyltetrazolium chloride (TTC) is used as an indicator dye that helps to observe electron transport system activity. The DHs involved in electron transport system reduce the colourless soluble TTC (substrate) and convert it into an insoluble red colour product, known as triphenylformazan (TPF). TPF can be quantified by spectrophotometry at the visible wavelength of 485 nm. Higher the intensity of the red colour in the soil extract solution, higher is the concentration of TPF and hence the higher DHs activity.

Furthermore, soil DHs activity was determined, as described previously, as the reduction of colourless TTC into reddish coloured TPF. The TPF was filter-extracted from the soil with methanol (Figure 1). The TPF was quantified by spectrophotometry as absorbance at 485 nm wavelength and the concentration was calculated by using the calibration graph prepared from TPF standards.

Data Analysis

Regression and analysis of variance (ANOVA) were performed by using statistical software R-3.1.3. Individual mean comparisons were made by LSD ($P \leq 0.05$).

Results

In this study, the results of DHs assay are derived from the final year (2014) of different 4-year crop rotations. The study clearly showed that frequent inclusion of pulse crops especially chickpea in the cropping systems is conducive to the soil biological activity.

In general, the July values of DHs activity appeared to be higher than those of September. This trend seems to be associated with mean temperatures of those months, July being much warmer (mean temperature ~ 18°C) than September (mean temperature ~ 12°C).



Figure 1: A snapshot of experimental site with lab set-up in inset.

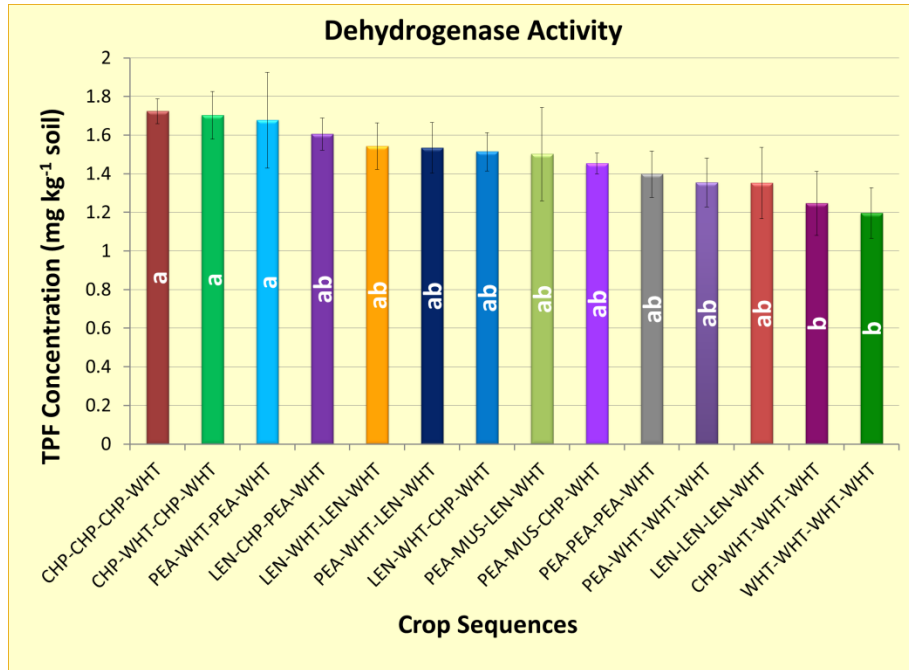


Figure 2: Soil dehydrogenase activity as an indicator of soil biological activity determined spectrophotometrically as TPF concentration in different cropping sequences. The bars are mean values of July and September 2014 and the error bars are the standard errors of the mean. The treatment means differed significantly ($P = 0.043$). The individual means with different letters in the bars differed significantly.

Frequent inclusion of pulses especially chickpea in the cropping system resulted in significantly higher soil biological activity ($P= 0.043$) than the sequence that involved repeated cropping with wheat (Figure 2).

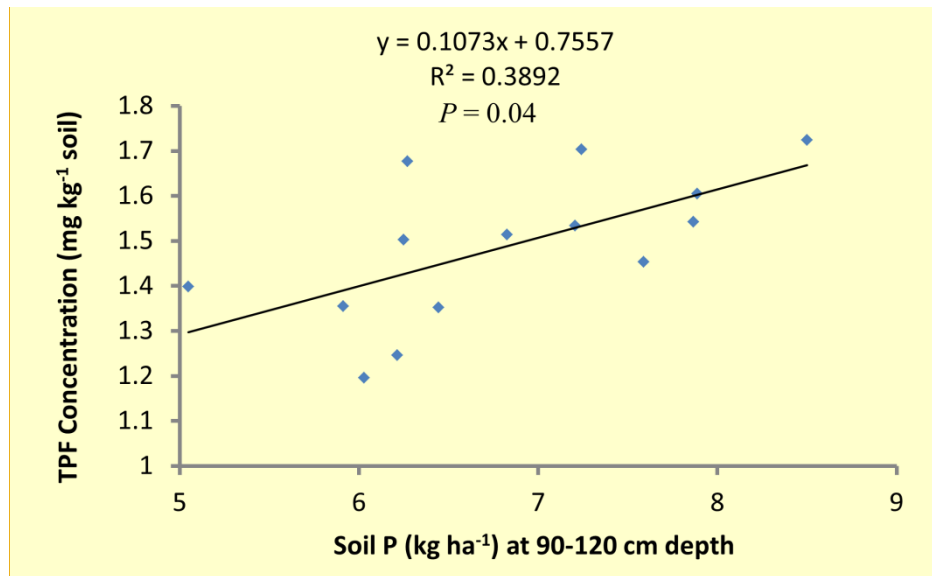


Figure 3: Regression of soil DHs on phosphorus content of the soil at 90-120 cm depth.

At the sub-soil region of the rhizosphere (90-120 cm) where the soil condition is relatively less aerobic, increase in phosphorus content of the soil resulted in significant increase ($P = 0.04$) in the microbial activity. It implies that the role of phosphorus is conducive to the soil biological activity in less aerobic conditions. (Figure 3).

Conclusions

Frequent inclusion of pulses in the cropping system can promote higher soil biological activity and thereby increasing the soil productivity and ecological sustainability.

The spring phosphorus content in the subsoil zone is positively correlated with the soil dehydrogenase activity. It implies that the role of phosphorus is conducive to the soil biological activity in less aerobic conditions. Thus, optimal phosphorus management is not only essential for soil productivity, but also for ecological balance.

Reference

Le Casida, J. R., Klein, D. A., & Santoro, T. (1964). Soil dehydrogenase activity. *Soil Science*, 98(6), 371-376.

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