Effect of Freeze-Thaw Cycles and Soil Water Content on Infiltration Rate of Saskatchewan Soils

Ymène Fouli, Barbara J. Cade-Menun, and Herb W. Cutforth

Semiarid Prairie Agricultural Research Center, Agriculture and Agri-Food Canada, PO Box 1030, Swift Current, SK S9H 3X2 Canada.

Keywords: freeze-thaw cycles, soil water content, infiltration, soil texture

Introduction

Freezing and thawing occur world-wide and can affect the quality and productivity of agricultural soils. Freeze-thaw cycles (FTCs) cause water and solute movement in the soil. The idea for this research topic came about as our team worked on the Saskatchewan's Watershed Evaluation of Beneficial Management Practices (WEBs). The goal was to characterize the Pipestone Creek watershed's hydrology by quantifying snowmelt and rainfall runoff versus infiltration, and studying winter/spring FTCs and infiltration rates. Questions were raised such as "what happens to some characteristics of SK soils that freeze and thaw, such as soil porosity, aggregate stability, bulk density, and infiltration rates? How do FTCs affect them? The objective of this study was to determine the infiltration rate of cold water (1-2^{o}C) into packed soil columns exposed to FTCs using different textured SK soils and different soil water contents at freezing.

Methods

Three Saskatchewan soils were used: a loamy sand, a loam, and a clay at two initial soil water contents corresponding to matric potentials 15 (permanent wilting point) and 0.33 (field capacity). The soils were set at a selected moisture content, packed into insulated aluminum cylinders, and subjected to FTCs. One full FTC corresponded to 12h at -10C followed by 12h at +2-4C. The control samples did not undergo FTCs. Cylinder dimensions were 21.5 cm tall with an inner diameter of 12.4 cm. Infiltration rates were measured using an 8-cm tension infiltrometer at 15, 10, and 5 cm tensions.

Preliminary Results & Discussion

Overall infiltration rate results showed that soil water content was a significant factor at the 5% level, and infiltration rates at 15 bar were higher than at 0.33 bar for all soils and all tensions. In addition, FTCs were a significant factor and infiltration rates at 0 FTC (control) were higher than at 1, 5, and 10 FTCs, indicating that FTCs affected soil porosity and permeability. The infiltrometer tension was also a significant factor and infiltration rates at 5 cm tension were higher than at 10 cm tension, which in turn were higher than at 15 cm tension. Soil texture was also a significant factor and infiltration rates in the clay soil were higher than in the loam or loamy sand, which were no different at the 5% significance level (Fig. 1). This indicates that soil porosity was higher in the clay soil than in the loam and loamy sand. The clay soil contained smectite and illite expansible silicate clays that may have resulted in shrinkage and cracking, resulting in the creation of larger pores and the potential for preferential flow. Freeze-thaw cycles decreased infiltration rates for the loamy sand and loam (Fig. 1), confirming the potential for surface sealing due to fine particle dispersion caused by stressful conditions. Infiltration rates in the clay soil increased (though not significantly) due to FTCs (Fig. 1).

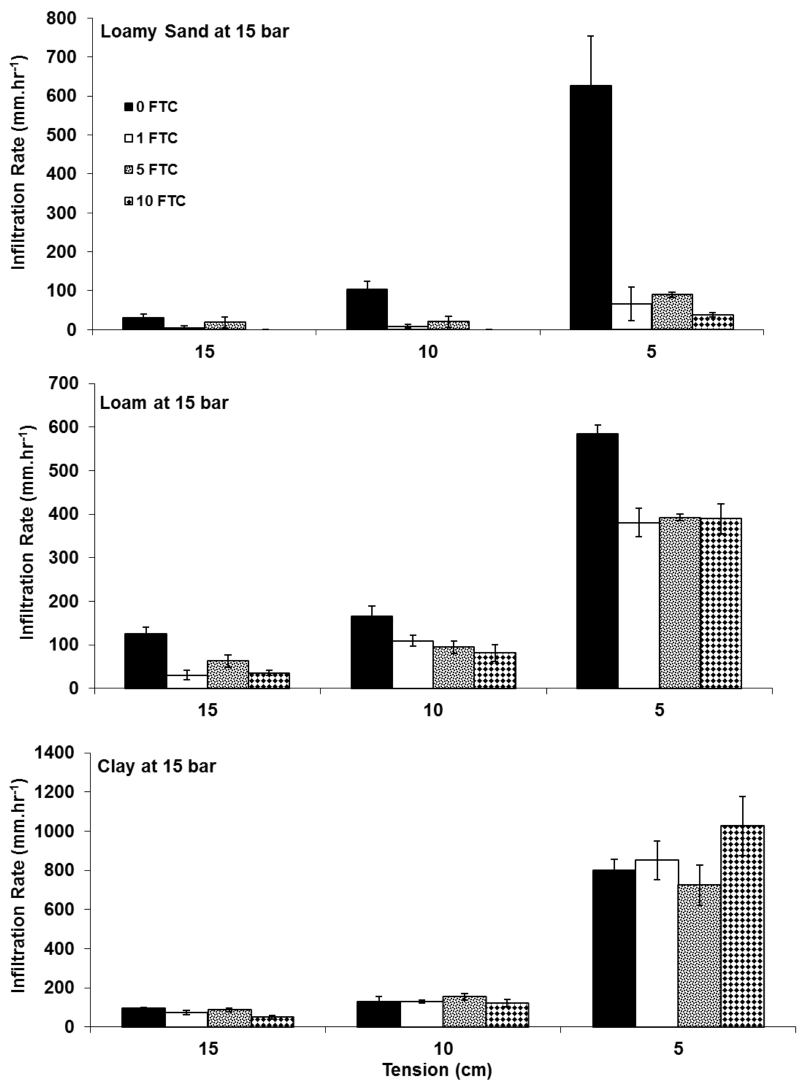

Fig. 1: Infiltration rates (mm.hr^{-1}) for all three soils (loamy sand, loam, and clay) at 15 bar at 15, 10, and 5 cm tensions.