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Soil displacement beneath an agricultural tractor drive tire

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Abstract

Soil strain transducers were used to determine strain in an initially loose sandy loam soil in a soil bin beneath the centerline of an 18.4R38 radial-ply tractor drive tire operating at 10% travel reduction. The initial depth of the midpoints of the strain transducers beneath the undisturbed soil surface was 220 mm. Strain was determined in the vertical, longitudinal, and lateral directions. Initial lengths of strain transducers were approximately 118 mm for the longitudinal and lateral transducers and 136 mm for the vertical transducer. The tire dynamic load was 25 kN and the inflation pressure was 110 kPa, which was a recommended pressure corresponding to the load. In each of four replications, as the tire approached and passed over the strain transducers, the soil first compressed in the longitudinal direction, then elongated, and then compressed again. The soil was compressed in the vertical direction and elongated in the lateral direction. Mean natural strains of the soil following the tire pass were −0.200 in the vertical direction, +0.127 in the lateral direction, and −0.027 in the longitudinal direction. The mean final volumetric natural strain from the strain transducer data was −0.099, which was only 35% of the mean change in natural volumetric strain calculated from soil core samples, −0.286. This difference likely resulted from the greater length of the lateral strain transducer relative to the 69 mm lateral dimension of the soil cores. The strain transducer data indicated the occurrence of plastic flow in the soil during one of the four replications. These results indicate the complex nature of soil

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movement beneath a tire during traffic and emphasize a shortcoming of soil bulk density data because soil deformation can occur during plastic flow while soil bulk density remains constant.

Keywords: Strain; Strain transducer; Plastic flow; Soil compaction; Deformation; Stress

Nomenclature

$\boldsymbol{l}$	current endplate spacing for strain transducer
$\boldsymbol{l}_i$	initial endplate spacing for strain transducer
$\boldsymbol{l}_x$	current endplate spacing for the longitudinal strain transducer
$\boldsymbol{l}_{x,i}$	initial endplate spacing for the longitudinal strain transducer
$\boldsymbol{l}_y$	current endplate spacing for the lateral strain transducer
$\boldsymbol{l}_{y,i}$	initial endplate spacing for the lateral strain transducer
$\boldsymbol{l}_z$	current endplate spacing for the vertical strain transducer
$\boldsymbol{l}_{z,i}$	initial endplate spacing for the vertical strain transducer
NT	Net traction of the tire
V	current volume of soil
V_i	initial volume of soil
W_d	dynamic load of the tire
$\bar{\boldsymbol{\varepsilon}}$	natural strain of soil between the endplates of a strain transducer
$\bar{\boldsymbol{\varepsilon}}_v$	natural volumetric strain of soil
$\bar{\boldsymbol{\varepsilon}}_x$	natural strain of soil in the longitudinal direction
$\bar{\boldsymbol{\varepsilon}}_y$	natural strain of soil in the lateral direction
$\bar{\boldsymbol{\varepsilon}}_z$	natural strain of soil in the vertical direction
ρ	current dry bulk density of soil
ρ_i	initial dry bulk density of soil
ρ_f	final dry bulk density of soil determined using soil core samples

1. Introduction

Vehicle traffic on soil occurs during crop production and this traffic often deforms and compacts the soil. Soil strain and compaction degrade soil by decreasing water infiltration and water holding capacity, increasing runoff and erosion, increasing crop production problems, thereby decreasing crop yields and profitability of farming systems. Strain may occur in soil without compaction occurring, and such strain can degrade the soil physical condition. For example plastic flow, which is the occurrence of strain without a change in volume, may occur. When plastic flow occurs, soil is not compacted, but the strain may decrease the connectivity of pores in the soil, thereby decreasing the water infiltration rate. Information about soil strain in three mutually orthogonal directions beneath a moving tractor drive tire is ex-