Effect of soil moisture, bulk density, and cone material on finite element prediction of soil hardpan

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Abstract.

An accurate soil hardpan determination is important for maximum precision tillage performance. Soil cone penetrometer data are often analyzed to predict soil hardpan depths. The prediction in layered soils may be limited due to the complexity of soil reaction to cone penetration. An axisymmetric finite element (FE) model was developed to investigate soil hardpan predictions and soil deformation failures on layered Norfolk sandy loam soil. The soil was considered as a non-linear elastic-plastic material modeled using a constitutive relationship from Drucker-Prager model with the Hardening option in ABAQUS, a commercially available FE package. ABAQUS/Explicit was used to solve the simulation of soil-cone contact pair interaction using a frictional property. The results showed that the FE model captured the soil cone penetration trend in layered soil with two deflection points indicating the start of the hardpan and the peak cone penetration resistance. The FE model predicted hardpan depth (8.62 cm) was smaller than the cone penetrometer predicted depth (11.03 cm). Soil moisture, bulk density and cone material significantly affected the FE and cone penetrometer predicted soil hardpan depths. The simulation also showed soil deformation zones about 3 times the diameter of the cone developed around the advancing cone.