Influence of selected tillage operations on draft power and penetration resistance of a crusting soil.

Abstract:

Depending on the top and subsoil textures, semi-arid soils exhibit cohesive and frictional properties that are associated with the relatively high soil strength, bulk density and penetration resistance. The objective of this study was to gain the knowledge of mechanical properties of the compacting chromic luvisols in order to improve the design of tillage tools. Therefore, we applied critical state soil mechanics to study the stress–strain behaviour of the luvisols using triaxial tests under laboratory conditions. Field investigations involved random collection of undisturbed soil samples which were subjected to triaxial testing first by isotropic consolidation and compression and then triaxial shearing. Plots of deviatoric stress against axial strain were made to determine the soil shear strengths at the critical states over different soil water levels and the two soil depths of 0–20 cm for the plough and 20–40 cm for the hard pan layers, respectively. An exponential model used to fit the deviatoric stress–axial strain test data accurately predicted the trends. Soil water significantly influenced the shear strength, cohesion (c') and internal angle of friction (ϕ') and hence the mechanical behaviour of the luvisols. The regression equations developed showed that c' and ϕ' have quadratic relationships with soil water. The very high clay bonding strength in the subsoil (hard pan) layer resulted in high shear strength, bulk density and penetration resistance values for this soil layer. The increase in shear strength with decreasing water content affected the deviatoric stress–axial strain relationships between the upper and lower plastic limits of the sandy soil. Thus, as the soil dried, the soil ceased to behave in the plastic (ductile flow) manner and thus began to break apart and crumble. The crumbling was indicative of brittle failure. The transition stage from an increase to a decrease in c' and ϕ' values with soil water occurred in the soil water content range of 6–10%. Knowledge of stress–strain behaviour of compacting soils is of practical significance in the design of appropriate tillage tools for the specific soil type