EARTHWORMS AND THEIR TUNNELS IN RELATION
TO SOIL PHYSICAL PROPERTIES

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by

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Summary

Physical modification of soil by earthworms has received limited scientific attention. With the use of limited tillage systems in agriculture and the compaction of agricultural soils by machinery, the role of biopores generated by earthworms for root growth and water and air movement is of increasing importance.

This work establishes the pressures exerted by a geophagous (soil ingesting) earthworm Aporrectodea rosea when tunnelling through soil. Axial forces were measured by directing earthworms to tunnel onto discs of soil mounted on an electronic balance. The area over which the force acts was estimated from the size of the hole created. The mean maximum pressure was 72.8kPa which is approximately one-tenth of the maximum axial pressure recorded for plant roots.

Radial pressures generated by the same earthworm species were measured in a study of the fracture of soil discs into which the worms were encouraged to tunnel. The tensile strength of replicate discs was determined by indirect tension tests and by the expansion of rubber membranes in soil discs. Mean values for the radial stress applied by the earthworms to tunnel through the soil discs was 230kPa. Both axial and radial pressures are related to the effectiveness of muscle contractions.

Physical properties of casts of the earthworm A. rosea were examined and compared with the properties of aggregates from the bulk soil. The shape of the earthworm casts and similar-sized soil aggregates were quantified by three ratio methods and two mathematical spectra using data obtained by two dimensional scanning. The tensile strengths of dry casts were measured by the indirect tension method and were approximately 2.5 times greater than those of dry aggregates of similar size. These tensile strengths are used to predict compaction characteristics of beds of dry casts and aggregates. From the relationship between soil water content, matric potential and undrained shear strength of fresh earthworm casts, the mean pressure applied to soil as it is remoulded by passing through the earthworm gut is estimated at 259Pa.
The morphology of tunnels made by earthworms in the field was also investigated. The coordinates of points along tunnels were measured during excavation. Descriptions as a function of depth include length, orientation and frequency of branching points. Mean tunnel length was approximately 400mm with typically 2-3 branching points. Soil carbon content was also determined in relation to depth. Positive correlations between tunnel length and organic matter in the profile were found for the geophagous species investigated. Maximum depth of the excavated tunnels was approximately 25cm, placing them entirely in the soil A horizon. Tunnel numbers per square metre were estimated by examining intercepts on horizontal cleavage faces at different depths.

Published values of soil ingestion rates and physical constraints on activity were used to develop an empirical model of earthworm movement through soil. The model allowed the partitioning of activity between arbitrary soil layers so that comparison of the model predictions was possible with the field studies.