ROOT GROWTH IN COMPACTED SOILS WITH FINE AND COARSE STRUCTURAL UNITS

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SUMMARY: Zea mays was grown in treatments with the same degree of compaction and the same water content where one treatment contained soil with coarse structure. In the other treatment, structure was physically destroyed by passing the soil through a 2-mm sieve. Growth of roots in the coarse-structured soil was faster and resulted in earlier extraction of water from the bottom layer. Response of rooting and water use to type of soil structure was greater in the harder clay than in the loam. Roots grown in fine structured soil were thicker and were characterized by tortuous growth. Top growth was better in fine structured treatment of the loam and in the coarse structured clay treatment.

1. INTRODUCTION: The effect of compaction level on root growth is closely related to soil strength and moisture status (BUSSCHER et al. 1987) and aeration which are influenced by type of soil aggregation (GLIŃSKI and LIPIEC 1990). It has been found that at low levels of soil compaction with smaller structural units, root growth was not impeded and the units were readily displaced by roots (LOGSDON et al. 1987). Finely aggregated soil can be conducive to both soil compaction (GLIŃSKI and LIPIEC 1990) and limited root growth. However, compaction of coarsely aggregated soil would have undisturbed interaggregated pores which may offer greater potential for root growth and thus for water absorption from deeper layers. The presence of larger biopores in untilled soil of high bulk density significantly facilitated root growth and increased the limiting value of mechanical impedance to root growth (EHLERS et al. 1983). The effect of the interaggregated pores may depend on type of soil and resulting strength properties.

Therefore, it is the purpose of this paper to compare the effects of compaction of fine and coarse structural units on root growth in two soils having different texture.

2. MATERIALS AND METHODS: Two soils of loam (12% clay) and clay (25% clay) textures were compacted to the bulk densities of 1.45 and 1.36 Mg m^{-3}, respectively. These densities correspond to 90%

of a reference bulk density (HÅKANSSON 1990) for both soils. In each soil the initial structures were either fine (obtained by pushing the soil through a 2 mm sieve) or coarse (with approximately 4-mm to 8-mm peds). Four replicates of each soil of each treatment were compacted in 8 liter containers (0.2-m cube). Both containers with fine- and coarse-structured soil were attached at the bottom to 0.1-m deep containers having loosely compacted soil. The lower container was separated from the top by 8 mm of gravel and it was maintained at a matric potential of -35 kPa.

Eight seedlings of maize (Zea mays) per one replicate were grown in a growth chamber with 14-h daytime temperatures of 25°C and nighttime temperatures of 18°C. The initial soil moisture content in the top 0.2-m soil corresponded to field water capacity. No water was added to any treatment. The values of soil strength in fine and coarse structured treatment were 1.6 and 2.1 MPa for the loam and 1.9 and 2.5 MPa for the clay. O.D.R. ranged from 41.4 to 47.6 $\mu g\ m^{-2}\ s^{-1}$ and was beyond the range considered as critical for maize growth. To minimize evaporation the soil surface was covered with an 8-mm thick gravel layer.

Withdrawal of water by roots from the bottom soil layer was measured using the negative pressure circulation technique (LIPIEC et al. 1988).

3. RESULTS: Root length density of maize was lower in fine than in coarse structured treatment of both soils (Figure 1). This effect was much more pronounced in the clay than loam. In addition, the roots grown

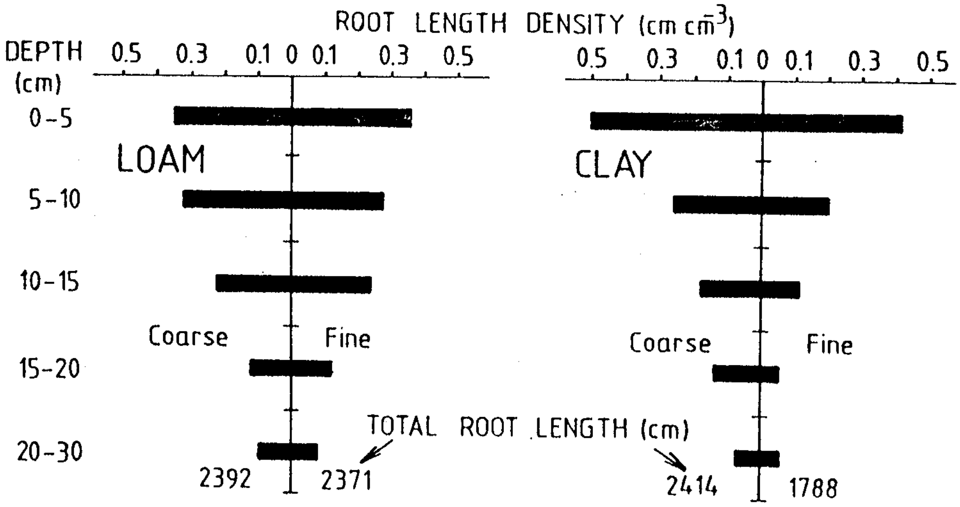

Fig. 1. Root length density for coarse structured and fine structured treatments.

in the fine structured treatment were thicker and had fewer branches. This response can be due to a lack of pores with diameters greater than the roots in the fine structured soil, despite lower soil strength when compared to the coarse structured soil. These results indicate that the influence of mechanical impedance on rooting may depend on the pore size distribution, especially for those pores with diameters greater than the roots. A limited view of characteristics through a clear plastic front of the soil containers showed that the coarse structured soil had visibly larger pores (up to 6 mm) than the fine structured soil.

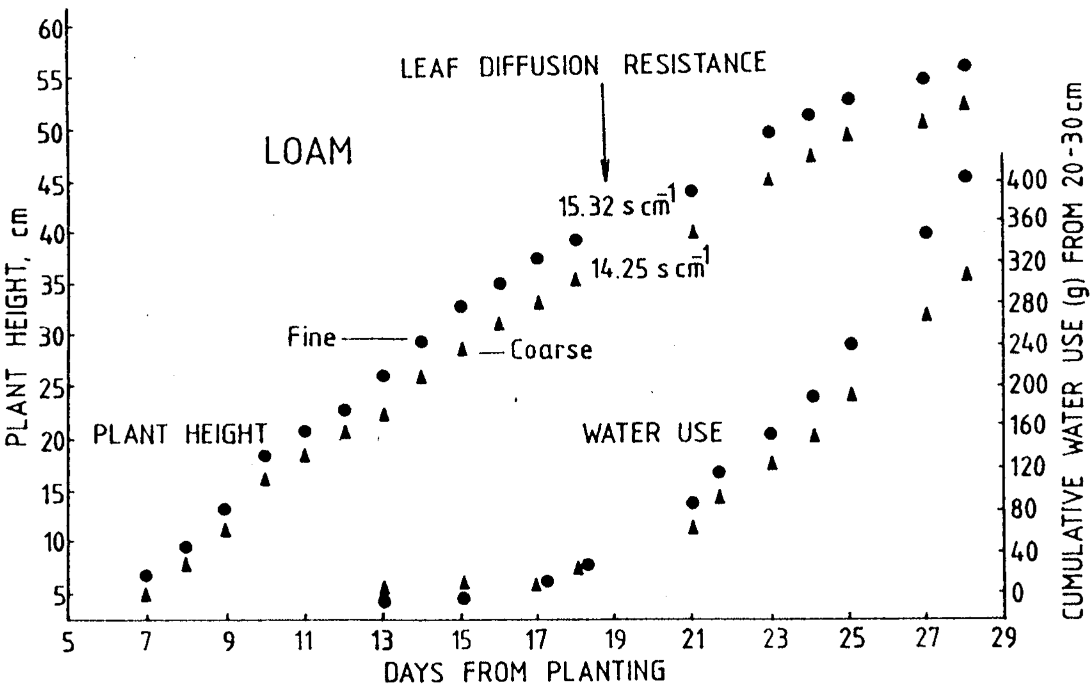

Fig. 2. Plant height and water use of the loam for coarse structured and fine structured treatments.

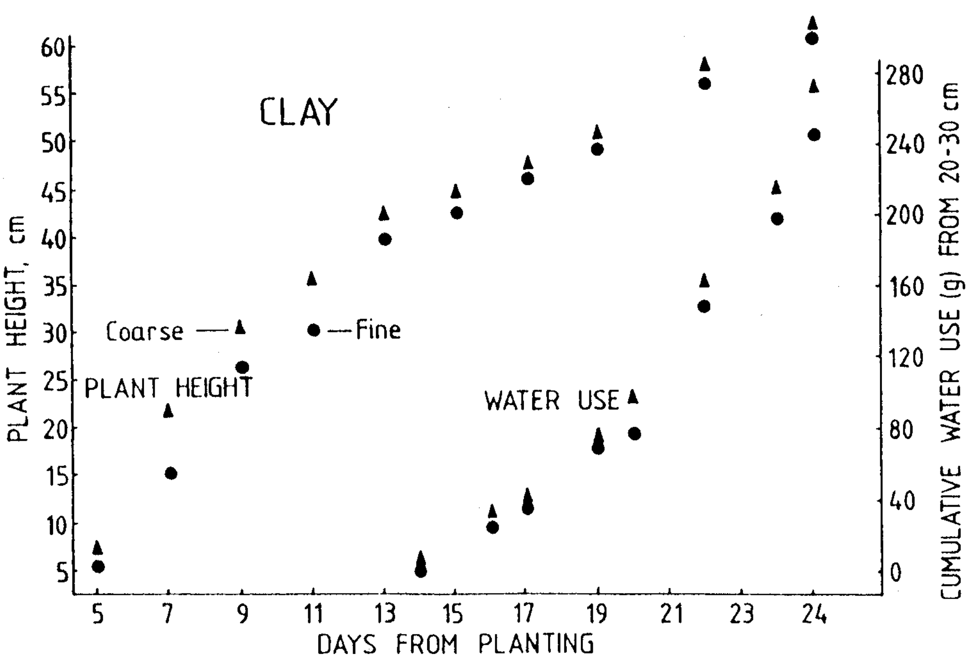

Fig. 3. Plant height and water use of the clay for coarse structured and fine structured treatments.

Roots of coarse structured treatments in both soils grew deeper faster and extracted water from the bottom layer sooner (Figures 2,3). Cumulative water use from this layer was greater in the fine structured treatment for loam and in coarse structured one for clay soil.

Top growth response as characterized by plant height (Figures 2,3), leaf area and top dry matter (Table 1) was better in coarse structured treatment for the clay and in fine structured treatment for the loam.

TABLE 1.: Some plant characteristics for coarse structured and fine structured treatments.

Plant Characteristics				
	Loam		Clay	
Structure	Coarse	Fine	Coarse	Fine
Leaf Area cm^2 8 $plants^{-1}$	673.9	719.8	860.1	705.2
Top Dry Matter g 8 $plants^{-1}$	2.04	2.58	2.94	2.30
RL/LA* cm^{-1}	3.55	3.29	2.81	2.53

* Root Length / Leaf Area

4. REFERENCES: Busscher, W.J., Spivey, L.D. Jr., and Campbell, R.B., 1987: Estimation of soil strength properties for critical rooting conditions. Soil Tillage Res., 9, 377-386.
Ehlers, W., Köpke, U., Hesse, F. and Böhm, W. 1983: Penetration resistance and root growth of oats in tilled and untilled loess soil. Soil Tillage Res., 3, 261-275.
Gliński, J. and Lipiec, J., 1990: Soil Physical Conditions and Plant Roots., CRC Press, Boca Raton, FL, 250 pp.
Håkansson, I., 1990: A method for characterizing the state of compactness of the plough layer. Soil Tillage Res., 16, 105-120.
Lipiec, J., Kubota, T., Iwama, H. and Hirose J., 1988: Measurement of plant water use under controlled soil moisture conditions by the negative pressure water circulation technique. Soil Sci. Plant Nutr., 34, 417-428.
Logsdon, S.D., Parker, J.C. and Reneau R. B., Jr., 1987: Root growth as influenced by aggregate size. Plant and Soil, 99, 267-275.

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