The Impact of Different Levels of Soil Compaction on Soil Physical Properties and Root Growth of Maize and Soybean Seedlings

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Abstract

Two factorial glasshouse experiments were carried out at the Soil Research Institute, Kwadaso, Kumasi to examine the effect of soil compaction on soil physical properties and root growth of commonly cultivated maize and soybean varieties in Ghana. There were five levels of soil compaction, using bulk density as an index of compaction, and three varieties each of soybean (Glycine max L.) and maize (Zea mays L.) in a completely randomized design (CRD) with three replications. The soybean and maize were grown in a stack of three polyvinyl (PVC) cylinders each of diameter 8.54 cm and height 15.5 cm filled with the test soil, and consisted of top, middle and bottom sections with a height of 2.5 cm, 5 cm and 8 cm, respectively. The test soil, Asuansi series (Ferric Acrisol) was equilibrated to a constant gravimetric moisture content of 18%, and uniformly compacted in the cylinders to the desired bulk densities of 1.1, 1.3, 1.5, 1.7 and 1.9 Mg m⁻³. The middle sections, to which the five compaction treatments were applied, were sandwiched between the top and bottom sections each of which had a bulk density of 1.1 Mg m⁻³. Saturated hydraulic conductivity varied between 25.6 and 44.2 mm h⁻¹ under bulk densities of 1.9 and 1.1 Mg m⁻³, respectively. The hydraulic conductivity decreased by 6.6%, 12.9%, 32.6% and 42.1% as bulk density increased from 1.1 to 1.3, 1.5, 1.7 and 1.9 Mg m⁻³. The distribution of roots in the three soil sections was assessed as the ratio of root length in each section to the total root length in the sections, expressed as percentage relative root length. The respective relative root lengths of the 1.1 and 1.9 Mg m⁻³ for soybean were 12.15% and 76.98% on the top section, 47.05% and 19.64% in the middle section, and 40.97% and 3.38% in the bottom section. Significant \( P < 0.05 \) varietal differences were recorded in root penetration ratio among the soybean varieties. Soybean roots were more sensitive to increasing soil compaction than maize. The ideal bulk density for the growth of soybean and maize was 1.1–1.5 Mg m⁻³ with 1.3 Mg m⁻³ being the most preferable based on the performance of measured plant parameters. The study has indicated that Anidaso, Nangbaar and Ahoto soybean varieties could generally show similar tolerance to varying levels of soil compaction. The three varieties of maize (Obatanpa, Enibi and Mamaba) studied also showed similar responses to soil compaction. The results could provide a firsthand information to breeders and crop growers on crop selection in compacted soils.