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Root-soil contact of maize, as measured by a thin-section technique

III. Effects on shoot growth, nitrate and water uptake efficiency

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Abstract

Whilst adverse effects of soil compaction on plant growth are well known, experimental evidence also suggests that a very loose soil can adversely affect crop growth. We tested the hypothesis that poor root-soil contact in a loose soil is partly responsible for the existence of an optimum in the response curve of crops to soil compaction. In a pot experiment with maize at restricted nitrogen supply, five levels of soil compaction were compared and the percentage root-soil contact was measured in three of these. At the highest soil porosity tested, shoot growth was slightly slower than that at intermediate soil porosity. In the more compacted soil, shoot growth clearly lagged behind. Shoot fresh weight per unit root length decreased with increasing soil porosity over the whole range tested. In the most compacted soil, roots were mainly restricted to the upper zones of the pot and total root length was smaller than in less compacted soil. Water and nitrate uptake were highest at the intermediate pore volume and slightly lower at the highest soil porosity. Water absorption and nitrate uptake per unit root length decreased from compacted to loose soil with decreasing root-soil contact. This effect was more than proportional with the percentage root-soil contact and was in line with a correction value based on a transport model.

Introduction

Negative effects of soil compaction on crop growth have received much attention, but experimental evidence suggests that a very loose soil can negatively affect crop growth as well (Boone, 1988; Boone et al., 1987; Eriksson et al., 1974; Soane, 1985). The response of crops to soil density passes through a maximum which may be explained by the fact that, on the one hand, root penetration is easier and oxygen supply is better in loose than in compacted soil, and, on the other hand, the uptake rate of water and nutrients per unit root length in loose soil may be restricted by incomplete root-soil contact as well as by unfavourable transport characteristics of the soil. If sections of a root have no contact at all with the soil matrix, they cannot contribute to water uptake, unless vapour transport of water plays a role (Dalton, 1989). De Willigen and Van Noordwijk (1987) derived an equation predicting the effect of incomplete root-soil contact on the length of the period that nutrient supply to the root by diffusion can meet crop