Distribution of spring barley roots in Danish soils of different texture and under different climatic conditions

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Summary Spring barley root profiles have been investigated in three years with different climatological conditions during the growing season. In total, 50 root profiles were determined by measuring cm root/ml soil in different 10 cm sections of the profile. The investigations show that the root density was nearly identical for all soil types within the upper part of the plough layer. The decrease in root density with depth is most pronounced for the sandy soils and less for the loamy soils. The mean max. root depth in the sandy soils was roughly 70 cm, while it was roughly 140 cm for the loamy soils. A comparison between the clay and silt content in the subsoil and the thickness of soil layers with more than given root densities shows that there is no correlation between texture and thickness of soil layers with more than 1.0 cm root/ml soil, while there was a clear, positive correlation between thickness of soil layers with lower root densities and the clay and silt content in the subsoil. The different climatological conditions during the growing season give rise to differences in the root development. Very wet springs seem to impede root development in loamy soils with slowly permeable subsoils, while this is not the case in the sandy soils.

Introduction

The root development of different crops is strongly related to the climatic conditions during the growing season and to soil-physical and soil-chemical parameters such as texture, structure, bulk density, pore size distribution, and pH. Investigations show that in Denmark the root development in pure sandy soils will not be so deep as in more clayey soils\textsuperscript{11,13,17}. This is probably due to higher mechanical resistance to root penetration in sandy subsoils than in more clayey ones, where the clay minerals react as 'lubricants' for root penetration\textsuperscript{7}. Investigations of\textsuperscript{1,7,9,16} show that a clay content around 10–20% is most favourable for root penetration, probably because higher clay contents increase the cohesion of the soil. In profiles with non-sandy subsoils bulk density, soil structure and pH seem to have strong influence on the root penetration. Investigations of\textsuperscript{2,18} show a decrease in root penetration with increasing bulk density, and\textsuperscript{20} found in experimental series with sieved soil that the root penetration of cotton seedlings nearly stopped at bulk densities above 1.6–1.7 g/cm\textsuperscript{3}. Under natural conditions the soil structure makes root penetration possible into soil
layers with higher bulk densities. In that cases the roots follow weak zones between the aggregates, while only few roots penetrate into the aggregates. In that way roots might penetrate a plough pan and reach parts of the subsoil with lower bulk densities. The root development is strongly related to soil aeration because of the root respiration. As the $O_2$- and $CO_2$-diffusion is much faster in airfilled pores than in waterfilled the $O_2$- and $CO_2$-diffusion is closely related to the airfilled pore volume. Slowly permeable subsoils might cause bad aeration in the soil and impede root growth especially in wet springs with huge precipitation surplus. In humid regions as Denmark strongly leached soil might develop. In such areas low pH-values might still exist below the plough layer, although this is limed. In soil layers with pH-values below 4.5, aluminium might be toxic and restrict root growth.

In order to evaluate the quality of soils for plant production and to estimate the need of water for irrigation, it is necessary to have information on root development for different crops in relation to soil types and climatic conditions during the growing season. Such studies have therefore been carried out in Denmark during the last decade, especially for calculation of the effective root depth for grass, spring- and winter-sown cereals, and beets.

This paper deals with a comparison of the root development of spring barley in different soil types in 1977, 1980 and 1983.

Materials and methods

Investigation areas

In 1977, 16 spring barley root profiles developed in homogeneous parent material were investigated west of Vejle in Jutland. The investigation area consists of loamy Weichsel till, dune sand, and sandy meltwater deposits. Pedologically, the loamy Weichsel till was luvisols and acrisols, some with pronounced pseudogley features in Br and C. The dune sand was podzol with cemented spodic B-horizons, while the meltwater deposits were podzols with non-cemented spodic horizons.

In 1980, 12 spring barley root profiles developed in homogeneous parent material were investigated within the glacial region of Himmerland, Northern Jutland. This region consists of sandy and loamy sandy till or melt water deposits and in few places of loamy till or dune sand. Pedologically, the sandy deposits are podzols with non-cemented B-horizons, or they are cambisols. The loamy tills are luvisols or acrisols some having pronounced pseudogley features in B and C.

In 1983, root investigations were carried out in Western Jutland and on Zealand. In Western Jutland 14 spring barley root profiles developed in homogeneous, sandy parent material were investigated. Geologically, the parent material was Saale deposits or outwash plains from the last glaciation period. Pedologically, it was podzols with non-cemented spodic horizon normally with gley features in the C.

On Zealand 6 root profiles were investigated in homogeneous mainly calcareous loamy Weichsel till. Pedologically, the soils were luvisols with pronounced pseudogley features, and in one case an acrisol.