

More than half of German agricultural soils exhibit severe barriers for root penetration

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Root restricting soil layers pose a barrier for vertical root elongation. This can severely hamper the productivity of agricultural land, especially in growing seasons with dry spells (limited accessibility of subsoil water) and in root/tuber crops (stunted growth). In the present study, we used the first German Agricultural Soil Inventory to examine the extent and causes of root restrictions in German crop- and grasslands.

The dataset consisted of 3,078 sites covering German agricultural land in a grid of 8 km x 8 km. At each site, soil profiles were described and physico-chemical soil properties measured at five depths (0-10, 10-30, 30-50, 50-70 and 70-100 cm). Based on a thorough review of the literature, the following characteristics were defined as root restricting: shallow bedrock, rock fragments, cementation, compactness, sandy subsoil, anoxia and acidity. We defined moderate and severe levels of root restriction based on the full range of extracted values from the literature review. Our approach was validated using root counts from soil profiles under winter wheat (*Triticum aestivum* L.) and permanent grassland.

At 71 % of German agricultural soils, potential rooting was restricted to less than 100 cm depth. Most root restricting soil layers (62 %) were classified as severe. Subsoil root counts of winter wheat were 18 % lower in the presence of severely root restricting soil layers compared to soils without root restricting layers. In grassland, we observed even 30 % less roots in the presence of such layers. Soil compactness was the most common cause of root restriction affecting 46 % of agricultural land (51 % of crop- and 32 % of grasslands). However, in contrast to previous studies, we estimate that at only one fourth of compacted cropland, compaction was of anthropogenic origin. The remaining majority of compacted cropland was compacted because of soil texture and pedology.

Independent of their origin, root restricting soil layers limit the production capacity of agricultural land. Melioration measures will be discussed, which improve access to subsoils and their resources to make future farming less vulnerable and more sustainable.