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A new dimension to observations in minirhizotrons: A stereoscopic view on root photographs

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Summary With a stereoscope, as used for the inspection of aerial photographs, sequential photographs of roots obtained by the endoscope method from 'minirhizotrons' can yield much more information than hitherto. A series of photographs shows that most of the roots seen in a minirhizotron in grassland grew on the surface of the lexan tube, while there was a gap between the roots and the soil. Decay of the extensive root hair zones around the roots may make new root growth in the gap between rhizotron wall and soil invisible. Some consequences of these observations for the endoscope method are discussed.

Introduction

Since Sanders and Brown[9] published an improved method for root observation through tubes, 'minirhizotrons', in the field using fibre optics for photography, many root researchers have added small modifications to the method[2,3,12]. The advantages of the method are clear, as it is a nondestructive method, allowing frequent root observations in more replication and under more natural conditions than the large rhizotrons[1]. When compared with root densities obtained by washing soil samples, the relative amount of roots seen on the photographs were found to vary with depth in many cases.

Since 1980 we have used the method and performed calibration measurements on washed soil samples, for various crops and soil types. As improvements to the method we inserted insulation material into the tubes to prevent water condensation on the rhizotron wall and developed a technique for carefully inserting the tubes into prepared holes, pushing the tube upwards by placing plastic bars on the lower side to improve contact between soil and minirhizotron wall. Various angles for placing the tubes and various positions relative to crop spacing were tested. A 30-degree angle to the horizontal appears to be a reasonable choice for agricultural applications.

Still, some of the results are poor, as shown for example in Figure 1 for a grassland experiment. In the upper 10–15 cm of soil, root density on the photographs is relatively low, while the highest root density is observed at about 20 cm, which is not in agreement with washed samples. Initially we thought that disturbance of the local water balance might be responsible, as capillary rise to the soil above the tube is impeded. In early spring and during wet conditions, however, the phenomenon can be seen as well. In a number of crop/soil combinations problems occurred caused by a poor visibility of the roots, especially older brown roots. The use of colour film gave some improvement, but still the pictures were rather vague in certain periods (especially for sugar beet and grass on loam soils). The possibility of clay adhering to the tubes was considered, so the tubes were extracted for cleaning and then reinserted. This procedure may damage the roots and gives only a temporary improvement. It remained uncertain whether the phenomenon is the result of the observation technique or a consequence of the observation situation of roots growing along an unnatural interface.

For the interpretation of aerial photographs it is common practice to use a stereoscope on sequences of partially overlapping photographs[4]. The stereoscope makes it possible to see a three-dimensional image. We decided to test this method on root photographs. A similar technique has been used to analyze X-ray radiographs of soils containing earthworm channels[8].