Methods for Root Research published in:

TROPICAL SOIL BIOLOGY AND FERTILITY
A Handbook of Methods

Second Edition, 1993
CAB International, Wallingford, UK
ISBN 0 85198 821 0

Edited by J.M. Anderson & J.S.I Ingram

pp 31-36 and 132-144

3.3 ROOTS

Note: This section gives procedures for the study of the overall root pattern. A review of methodologies for estimating root biomass, production and estimating total root carbon input to the soil may be found in Appendix D ("Roots: length, mass, biomass, productivity and mortality").

Root research requires destructive sampling of the soil, often causing considerable disturbance to the plots. Space should be allowed for this when designing field experiments. Specific information of root systems (both vertical and horizontal) is important when trying to understand plant/input interactions and the correlative effects on soil fauna and microorganisms. Information on the lateral spread of root systems is essential in deciding on "guard" areas or borders in field experiments. Errors in interpreting results are easily made when no root information is available, as lateral spread of over 5 m (cassava) or up to 20 m (certain trees) is often more than expected. Information on rooting depth and distribution is also essential when placement effects are to be considered regarding plant nutrient uptake.

Apart from the two classical descriptions of root methods by Schuurman and Goedewaagen (1971) and Böhm (1979), a number of recent reviews is available on methods to quantify root development and functioning in the field: Caldwell and Virginia (1991), Mackie-Dawson and Atkinson (1991), Taylor *et al.* (1991), van Noordwijk (1987), van Noordwijk *et al.* (1992).

Three methods outlined below are based on the study of soil profiles from a soil pit. In soils without stones or woody roots a monolith sampler as described by Floris and van Noordwijk (1984) might have the advantage of less site disturbance, but generally soil pits are needed to have access to the root environment.

3.3.1 Root preparation on profile walls

A soil pit is dug close to the plant selected for study and by carefully removing soil close to the stem some main roots are identified; their course is followed by gradually removing the surrounding soil, using a pin. When all (major) roots within the first, say, 10 cm from the original profile wall have been exposed, a drawing is made e.g. on a 1:5 scale on graph paper (Figure 3.1), using pins to mark grid points in the soil. Unfortunately most fine roots will break off during this procedure, and so only a qualitative picture is obtained. Still, the method allows width and depth of the root system and branching pattern to be recorded. The response of the root system to heterogeneities of the soil, to transitions between soil layers, to cracks (clay soils) and channels in the soil (made by soil fauna and/or previous roots) deserves special attention.

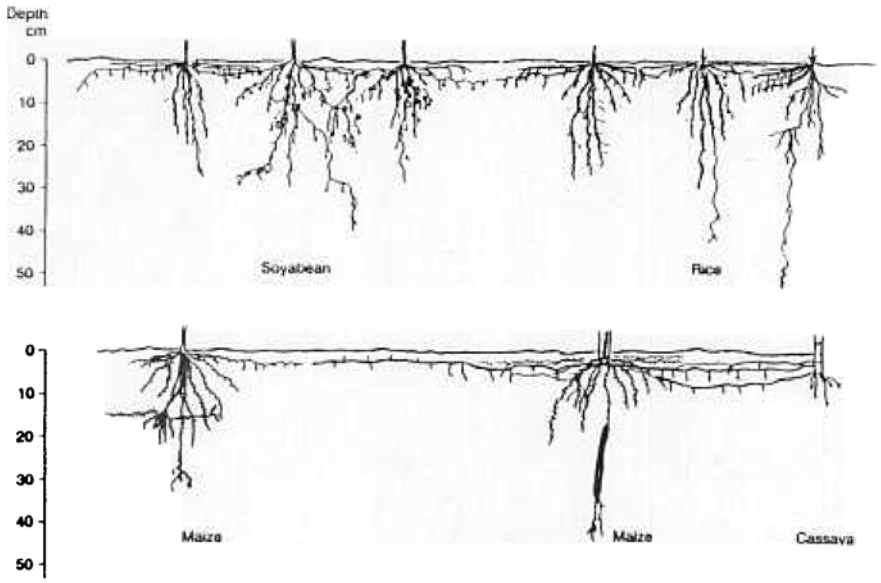

Figure 3.1 Example of root observations on profile wall, showing the response of maize roots to an acid subsoil (below 15 cm) and to the presence of old tree root channels (van Noordwijk *et al.*, 1991a).

In mixed cropping situations roots of the various components can usually be recognized after some training. By spending 1 to 2 days per major species the overall patterns of shallow and deep rooted species and lateral spread can be estimated: both are important when designing fertilizer or crop residue experiments or when designing mixed cropping systems. Results of this method are easily understood and can be used in discussions with e.g. farmers.

For shallow rooted crops lateral roots can also be observed from the stem base by digging a small trench, following the root. The presence of "sinker" roots, vertically oriented branch roots from a horizontal branch root, is of special interest here. By excavating a small area around the stem a classification of roots by diameter and orientation can be made (van Noordwijk *et al.*, 1991b). This way replicated observations can be made and a "typical" specimen can be selected for further observation.

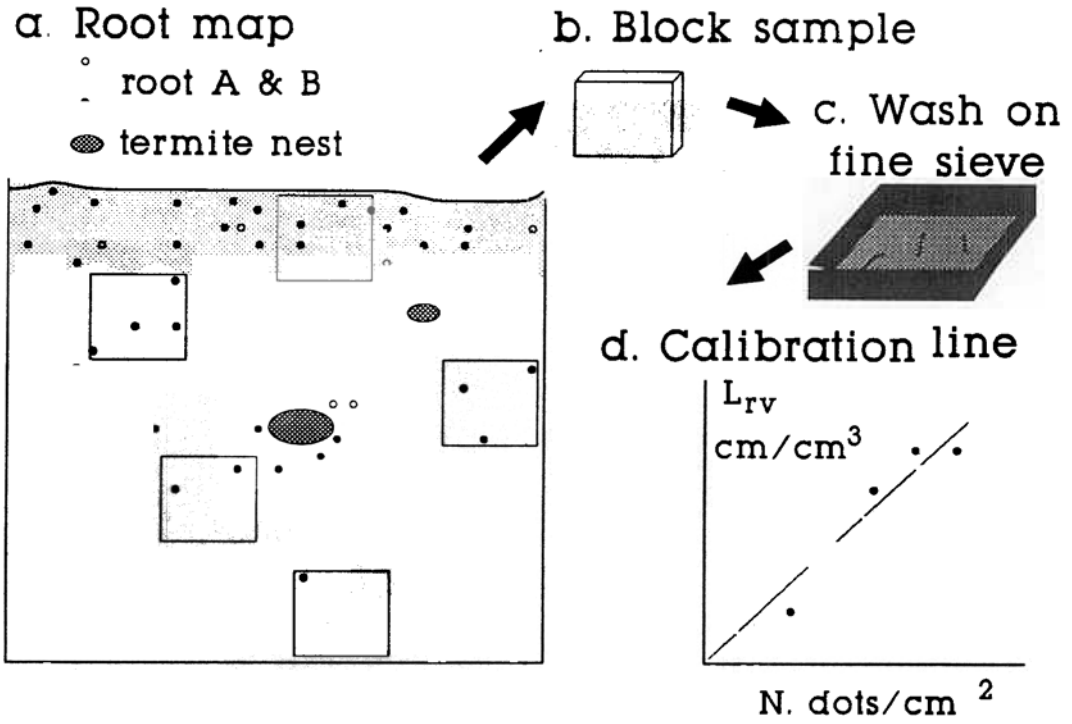

Figure 3.2 Root mapping on PVC sheets; roots A and B might refer to different diameter classes or species.

estimates can be obtained if root intensities in horizontally oriented planes are recorded as well (van Noordwijk, 1987). Experimental calibration factors may be considerably (e.g. three-fold) larger than theoretical ones.

Problems with the method are: (i) roots of different plants are hard to distinguish, (ii) distinction of live and dead roots is not easy and (iii) a considerable fraction of fine roots may be overlooked. To obtain (semi)quantitative results it is necessary to calibrate the maps by taking small blocks of soil (e.g. 20 x 10 x 1 cm volume) from various layers on the root map (Figures 3.2 b, c, d), wash them over a fine sieve (0.3 mm mesh) and determine root length (see below).

3.3.3 Pinboard monolith sampling

Monolith samples can be obtained with pinboards ("fakir beds"), made by inserting U-shaped pins (made from stainless steel) in plywood (Figure 3.3; further details are given by Schuurman and Goedewaagen, 1971, and Bohm, 1979). The size of the pinboard is determined by the crop (based on previous observations, such as rooting depth and distribution and practical considerations (samples of 100 x 60 x 10 cm of soil will weigh about 100 kg). By washing the soil away the roots become exposed and can be observed. If a coarse mesh screen (e.g. material used for TSBF litter bags) is put on the pins before the board is pushed into the soil (perpendicular to the crop row), this screen can help to keep the roots in their original location while washing the sample. Washing the sample can be facilitated by soaking overnight in water, deep freezing (for clay soils), soaking in oxalic acid

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3.4 LITTER DECOMPOSITION

3.4.1 Introduction

Decomposition is a complex process regulated by the interactions between organisms (fauna and micro-organisms), physical environmental factors (particularly temperature and moisture) and resource quality (defined here by lignin, nitrogen and condensed and soluble polyphenol concentrations) (Swift *et al.*, 1979). As decomposition progresses, soluble and particulate materials from the litter, organism tissues and products of microbial metabolism are separated from the original resource by leaching, physical fragmentation and animal feeding activities. These products are then transported by wind, water and gravity to soil microhabitats which have a different set of conditions regulating decomposition to those of the parent material. An almost intractable problem in quantifying litter decomposition is the need to impose methods which enable the experimental material to be identified without affecting the variables which regulate the component processes.

3.4.2 Litter bags and decomposition rate constants

Enclosing litter in a mesh bag makes it possible to recover the residual experimental material and defines the conditions under which the organisms operate. However, the mesh bag and