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Fractal Geometry in Root Systems : Quantitative Evaluation of Distribution Pattern

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Abstract:
In order to describe root distribution quantitatively, fractal analysis was applied to root systems. Root systems of soybean and garden pea seeldings grown in narrow root boxes (30×41×2 cm) were sampled with minimum disturbance of root arrangement using the root box-pin board method. Root samples were taken on 15, 25 and 41 days after sowing for soybean and 30, 55 and 94 days after for graden pea. The harvested root system was spread on the scanner bed connecting to a personal computer (Macintosh IIcx), and the root image was digitized with a 256 gray scale and 144 DPI resolution. Each image stored on a magneto-optical disks loaded on a MO disk drive (Reo drive, Yano Electric) was analyzed by the NIH Image software (ver. 1.5) running on a Macintosh computer (Quadra 800). The fractal dimension (D) of root images was estimated by counting the number of pixels constituting root image at various resolutions (box-counting method). D increased as the root system developed. D of the lower half (Dl) increased slowly compared with that of the upper half. This changing pattern of Dl corresponds well to the slower development of roots into the lower soil layer. The linear positive correlations were found between D and total root length (L) and between D and root projection area (PA). The correlation coefficients between D and L, and between D and PA were lower than that between L and PA. In soybean correlation coefficient between D and L was lower than graden pea, particularly in the lower half of the root system. These results indicate that fractal analysis is applicable to root systems, and that the D can be an effective parameter describing root morphology quantitatively.

Keywords:
Fractal, Root box, Root length, Root morphology, Root system

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