Rooting profiles with depth – the case of the Wurzelatlas mitteleuropäischer Ackerunkräuter und Kulturpflanzen

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ABSTRACT

The drawings in the Wurzelatlas mitteleuropäischer Ackerunkräuter und Kulturpflanzen (Atlas of Central European weeds and arable crops, but also in the Atlases by Kutschera et al.) offer a unique opportunity to analyze rooting patterns of very different crops and herbs determined using a consistent methodology. Using 203 drawings, the images of the rooting patterns with depth are analyzed. As a result, we obtain a relation between pixels and depth which can be subject to different conversions, and to different analyses, e.g. the mathematical description of the changes in rooting pattern with depth, or the distribution of interroot distances with depth. Subsequent analyses allow correlating the parameters of this description to soil and location parameters. Some results will be presented and discussed in relation to water uptake of the different species.

KEYWORDS: image analysis, root water uptake, rooting pattern

INTRODUCTION

Reviews of root density profiles as determined in field experiments have been presented by O'Toole and Bland (1987) for crops; by Gerwitz and Page (1974) for horticultural species; and by Jackson et al (1996), and Schenk and Jackson (2002) for different biomes. At the field scale rooting patterns are generally heterogeneous; those of agricultural crops are influenced by local conditions such as tillage, fertilization and nutrient availability, and other soil factors such as chemistry and texture.

THEORY

The drawings in the Root Atlases (Kutschera and coworkers) can be digitized and analyzed, yielding realizations of rooting patterns. These can be described mathematically. Quantifying the description of the site, statistical analyses may show significant factors determining rooting patterns. Water balance models can then be used to assess the sensitivity of water balance terms to rooting patterns on different temporal scales.

METHODS

Images available were 208 scanned originals of the first Root Atlas (Kutschera, 1960).
After resizing, thresholding, creating binary images, and subsequent skeletonizing, the binary images were analyzed in terms of the relation root pixels total versus depth in pixels. The procedure then followed was to fit polynomial splines of increasing order to the data. The spline of the order for which the marginal rate of return (in terms of variance explained per order added) was highest was selected to classify the root distribution patterns. These patterns were then correlated with the soil characteristics using linear regression. In addition consequences of different rooting patterns were simulated for three years using a water balance model assuming a

homogeneous soil, and a constant year round vegetation cover (grass-like) for Dutch conditions, with a 60 cm rooting depth, and ground water level at roughly 75 cm.

RESULTS AND DISCUSSION

Figure 1 shows the results of the analysis of Zea Mays (Figure 63 in Kutschera, 1960)).
58 % of the rooting patterns from the Wurzelatlas mitteleuropäischer Ackerunkräuter und Kulturpflanzen was best described by either a first, or a second order spline, which yield linearly decreasing or unimodal functions. An additional 22% of the rooting patterns is described by 3rd and 4th order splines. The remaining 20% requires more complex splines. Figure 2 shows the cumulative distribution of splines of a increasing order. Correlations between number of soil layers, or thickness of the soil layers, and rooting pattern complexity (i.e. order of the spline) were non-significant. A first exploratory use of these rooting patterns in a simulation study suggests that under Dutch conditions with a shallow ground water level these differences in rooting patterns do not lead to important changes in the waterbalance on a yearly time scale (2-5%). The effect is larger in a drier year.

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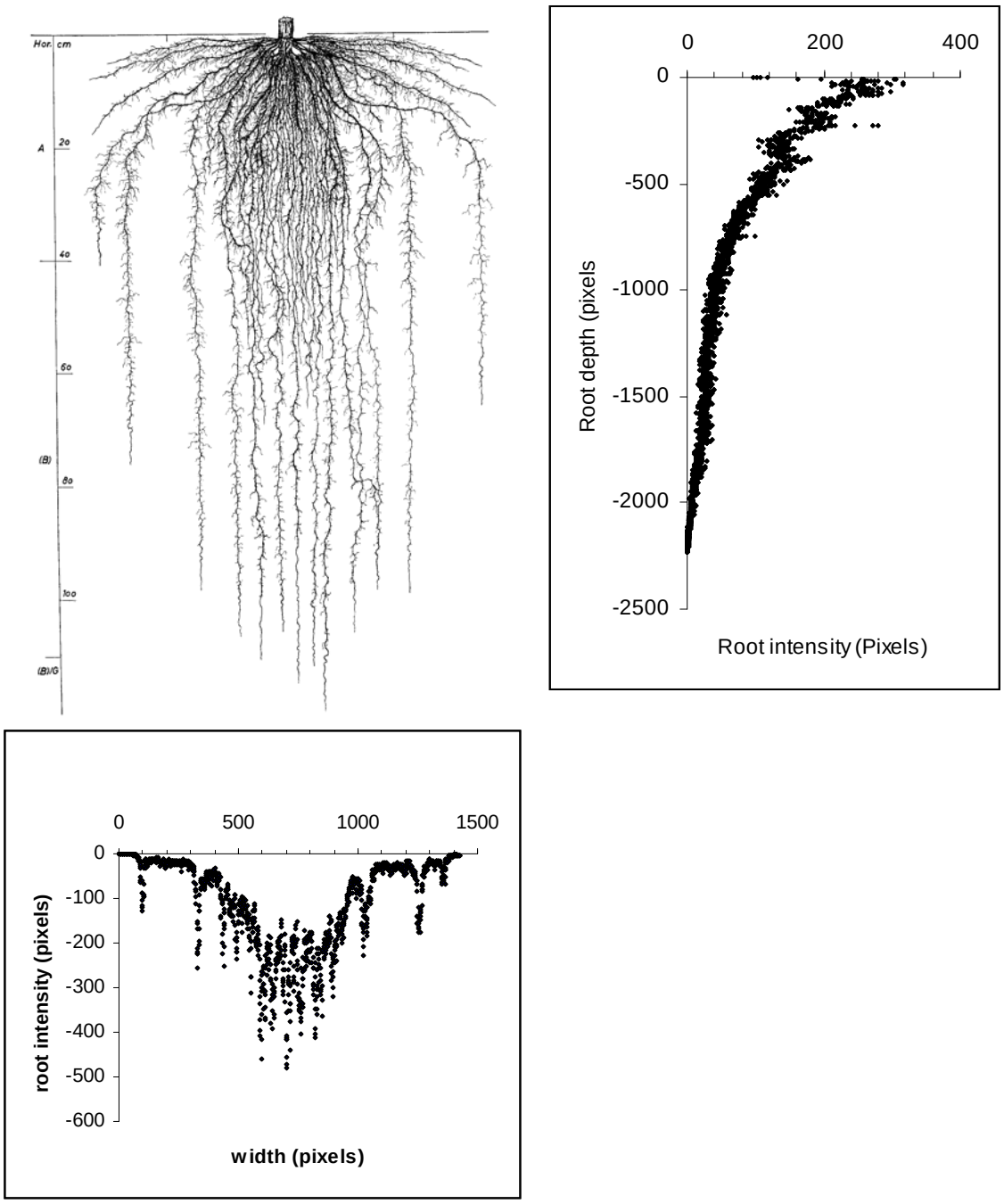

Figure 1. Original drawing, upper left corner, Analysis rooting pattern with depth right; and analysis lateral profile (bottom left). Results of analysis of the rooting pattern were fitted using polynomial splines. These fits were then subject of further analysis.

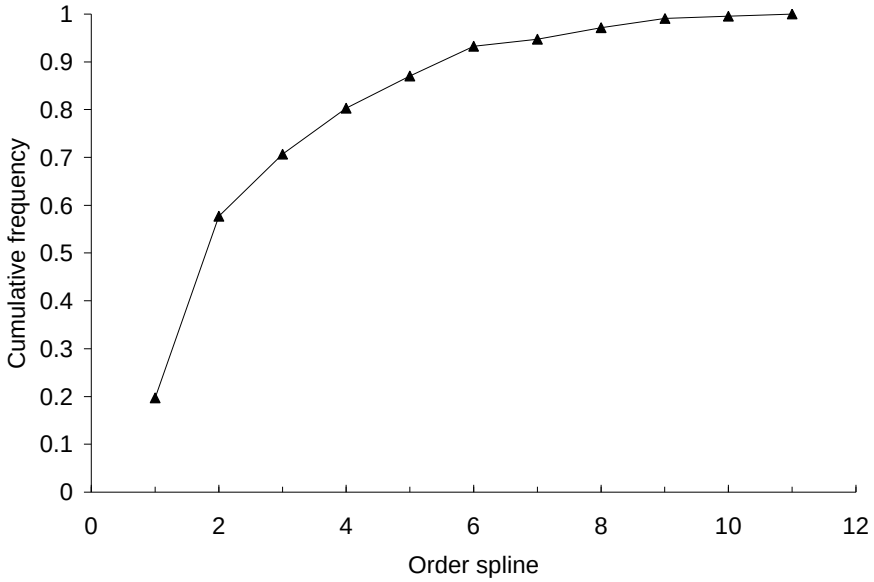

Figure 2. Cumulative frequency of polynomial splines used to fit the rooting pattern in the the Wurzelatlas mitteleuropäischer Ackerunkräuter und Kulturpflanzen