Lehr- und Forschungszentrum für Landwirtschaft
Raumberg-Gumpenstein

62. Tagung der Vereinigung der Pflanzenzüchter und Saatgutkaufleute Österreichs 2011, 101 − 103
ISBN: 978-3-902559-74-6

Root characteristics of durum wheat and wheat relatives

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Abstract

Access to a rich genetic diversity, and easy and feasible screening methods are main prerequisites for an efficient breeding program. Under drought condition, roots could play an outstanding role to improve yield by effective absorption of water from soil. Since roots are not easily accessible, root characteristics are hardly exploited in crop breeding so far. In the present study the diversity of root properties of 7 durum wheat genotypes and 5 relatives was determined in 3 soil depths, i.e. 10-20, 30-40 and 50-60 cm, of a field trial. As an easy and non-destructive field screening method in regard to root system size, electrical capacitance was assessed for its efficiency to predict 'true' root characteristics. The results revealed significant differences between genotypes and soil depths. A significant and positive correlation between root capacitance and/or root length and root surface indicates the capability of this method for the screening of genetic material under field conditions.

Keywords

Einkorn wheat, Khorasan wheat, root image analysis, *Triticum durum*, *T. timopheevi*

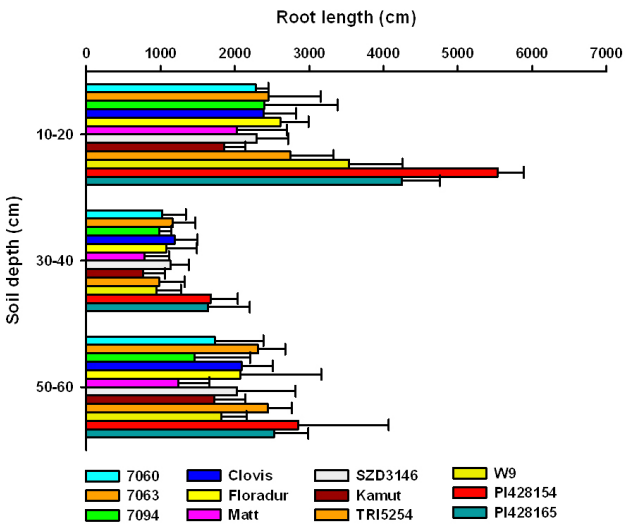

Figure 1: **Root length of different wheat material in three soil depths** (mean values + standard deviations)

Introduction

Improving abiotic stress resistance is a major challenge for plant breeding. Especially drought is among the most important environmental constraints to plant growth. LEVITT (1980) identified three main responses to water stress in natural plant communities: (i) drought escape, (ii) dehydration tolerance and (iii) dehydration avoidance. Dehydration avoidance may be achieved by reduced losses ('water savers') and improved supply ('water spenders'). Although the plant root system is essential to ensure an efficient water uptake (BLUM 2009), it is still hardly exploited in plant breeding (PALTA et al. 2011). A targeted integration of the root system into plant breeding requires knowledge on the existing diversity in root traits. The objective of the current study was to assess root system properties in different durum wheat genotypes and selected accessions of relatives. The main distinguishing features of root system diversity within this nursery are presented.

Material and methods

Plant material

Seven durum wheat (*Triticum durum*) genotypes, i.e. 7060 (CDSS02Y01022T-0TOPB-0Y-0M-21Y-0Y), 7063 (CDSS02Y01082T-0TOPB-0Y-0M-11Y-0Y), 7094 (CDSS02B00667S-0Y-0M-10Y-4M-04Y-0B), Clovis, Floradur, Matt and SZD3146, two Khorasan wheat (*T. turanicum*), i.e. QK-77 (Kamut®) and TRI5254, two einkorn wheat (*T. monococcum*), i.e. PI428154 and PI428165, and one Zanduri wheat (*T. timopheevi*), i.e. W9, were tested in a field experiment with 4 replications. The field trial was sown on 8 March 2011 in Raasdorf (16°35'E, 48°14'N) in the Pannonian plains growing region of Eastern Austria. Plot size was 1.75 m² (1.4×1.25 m).

Trait measurements

Electrical capacitance was measured by an Escort elc-133 lcr-meter (CHLOUPEK 1977) at the physiological stages stem elongation, inflorescence emergence and development of fruit. Thereby, an estimation of root system size was obtained. On 16 June (milk dough stage) the roots were sampled from 3 soil depths (10-20, 30-40 and 50-60 cm) by means of a single root auger from the center of each plot. Samples were stored at -20°C until final processing. After

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storage the samples were defrosted at room temperature. Then the roots were washed and sieved (pore size 0.63 mm). To prepare the roots for scanning they were coloured by an azur eosin methylene-blue solution (1:20 v/v). After staining the roots were scanned by a flat bed scanner and analyzed by winRhizo software (Regent Instruments Inc., Québec City). Measured root parameters included root length, root diameter, root surface and root volume. To measure root dry matter the roots were dried at 60°C and weighted after 24 h.

Results and discussion

This study revealed significant differences between genotypes and different soil depths for all investigated root characteristics. Root length varied from 4049.6 cm (durum cv. Matt) to 10065.3 cm (einkorn PI428154) with an average of 6004.3 cm. All genotypes showed their maximum and minimum root length in the upper and intermediate soil layer, respectively (*Figure 1*). The einkorn wheat accessions showed a significantly higher root length in all three soil depths compared to the other genotypes.

Concerning root surface area an average value of 774.0 cm² was estimated; with a minimum of 502.6 cm² for durum cv. Matt and a maximum of 1123.0 cm² for einkorn accession PI4281154. Root diameter varied between 0.368 mm (PI4281154) and 0.455 mm (Clovis). *Figure 2* shows a part of the observed root diameter diversity. In regard to root volume, minimum and maximum values were obtained for Matt (5.15 cm³) and PI4281154 (10.12 cm³), respectively. Root dry matter varied significantly between 440.4 mg (Matt) and 912.6 mg (Floradur) with an average of 623.3 mg.

As it is shown in *Figure 3* a significant correlation between electrical capacitance and root length was obtained ($P \leq 0.0001$). Moreover, similar correlations were observed between electrical capacitance and root surface and root diameter, respectively ($P \leq 0.0001$). Since electrical capacitance is an easy and non-destructive measurement it could be suggested as a feasible method for screening of genetic material for root system size under field conditions. In cereals the methodology was successfully deployed to study root system size of oats (CHLOUPEK 1972, 1977), the effect of semi-dwarf genes on root system size of barley (CHLOUPEK et al. 2006), to select barley for drought tolerance (CHLOUPEK et al. 2010), and recently to study the diversity in water use efficiency of wheat varieties (STREDA et al. 2012). Drawbacks of the method is the lack of knowledge concerning the electrical circuit of the system. Values are only comparable for plants of the same species grown in the same substrate, at the same soil moisture (a moist medium around the plant root system is necessary) and measured at the same time. The measured aerial parts must be dry (no precipitation immediately before or during measurements), dry leaves at the basal stems have to be removed, the electrode must be consitantly placed (CHLOUPEK et al. 2006), and development stages have to be considered in the analysis.

To summarize, this study confirmed a considerable variation concerning the investigated root properties and also the capability of electrical root capacitance measurements as

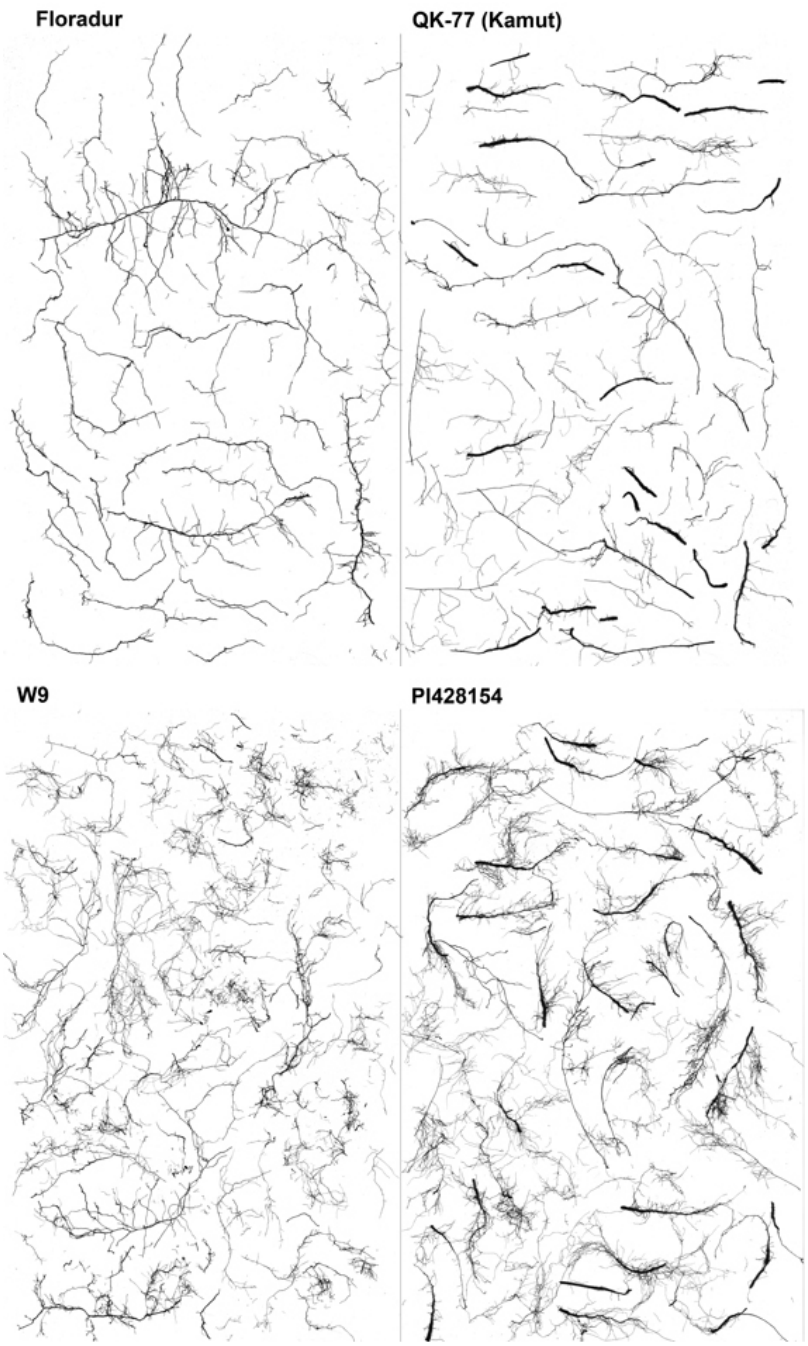

Figure 2: **Scanned roots from 10-20 cm soil depth for Floradur (*T. durum*), Kamut (*T. turanicum*), W9 (*T. timopheevii*) and PI428154 (*T. monococcum*)**

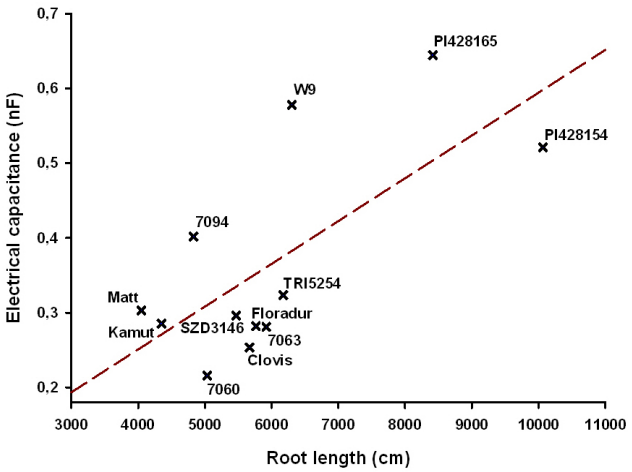

Figure 3: **Relationship between root length and electrical capacitance (measured at milk dough stage on 17 June) for different wheat material**

an easy and feasible method for the screening of genetic material under field conditions. Further experiments with non-destructive methods for studying root architecture are necessary to better understand the differences between the studied genotypes.

Acknowledgements

The genebank curators H.E. Bockelman (USDA-ARS, Aberdeen), A. Graner (IPK, Gatersleben), T. Payne (CIMMYT, Mexico) and J. Lafferty (SZD, Probstdorf) are kindly acknowledged for providing the original seeds of the tested genotypes.

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