Root distribution of winter wheat cultivars as affected by drought

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ABSTRACT

Drought stress is one of the main environmental factors limiting crop yields. Choice of drought-resistant cultivars may minimise yield-losses under water-limited conditions. The development of a deeper root system contributes to increased drought resistance.
Based on this information, the genotypic variation in root system distribution in winter wheat was examined in a field experiment either under natural rainfed conditions or with an induced water deficit. The distribution of roots was quantified at the wax-ripe stage (EC 83).
Root length densities were highest in the top 20 cm. Drought-stressed plants tended to produce less overall root length, and cultivars differed significantly in overall root lengths produced. Cultivars seemed to differ in their reaction to drought stress, but the difference was not significant.
In conclusion, data from additional growing seasons will be necessary to confirm variation in root distribution between cultivars in their response to drought-stress.
KEYWORDS: wheat, drought, root distribution, genotypic variation.

INTRODUCTION

Drought resistance may besides other factors be conferred by the development of a deeper root system giving crops access to water from deeper soil layers. Measurements of root depth distribution are however time-consuming and labour-intensive. As a consequence only limited information is available about the genotypic variation in these traits. The aim of this study was to quantitatively describe the root depth distribution of four field-grown winter wheat cultivars. Plants were grown under either natural rainfed conditions or with an induced water deficit.

METHODS

Samples were taken in a field experiment conducted by the ‘Institut für Sortenwesen’ of the Austrian Agency for Health and Food Safety. It was located in the dry region of north-eastern Austria (E 16° 49’ N 48° 18’; average yearly rainfall: 540 mm). The soil at the site is a Tschernosem with a moderate water holding capacity. Twelve winter wheat genotypes were grown in two adjacent experiments on small plots (3.2-3.3 m² net area) randomised in three replicate blocks. One experiment was exposed to natural rainfed conditions throughout the entire growth period. Foil tunnels with rollable foil were raised above the other experiment at the end of shooting. Plants in this experiment were exposed to ambient conditions during most of the time but received 143 mm less rain than uncovered plants until the wax-ripe stage. At this time, soil cores to a depth of 1 m were taken between the rows of four selected winter wheat cultivars. Cores were separated into 20 cm soil layers. Roots were washed out of the soil and their lengths were determined by a line-intersect method (Newman, 1966).

RESULTS and DISCUSSION

Root length densities (RLD) of all cultivars ranged from 2.5 to 4.5 cm g^{-1} soil in the top 20 cm (Figure 1) which is comparable to previously reported values (Ford et al., 2006). RLD decreased

to 1 to 1.5 cm g^{-1} in 20 to 60 cm soil depth but increased again in the 60 to 80 cm soil layer. The lowest RLD of < 1 cm g^{-1} were measured for the 80 to 100 cm soil layer. This pattern of root distribution was consistent for all genotypes. The observed increase in RLD at 60 to 80 cm soil depth may be due to a relative to the above-lying layers higher water content of the 60 to 80 cm soil layer which may have stimulated root growth (Xue et al., 2003).

Cultivars seemed to differ in their reaction to water stress which is exemplified by the two examples given in Figure 1. RLD of cultivar A (left graph) were reduced under water stress in all but the deepest soil layer examined. Contrary to that, cultivar B (right graph) produced higher RLD in the 40 to 80 cm soil layer under water stress than when exposed to natural rainfed conditions. Differences in cultivar RLD were however not significant.

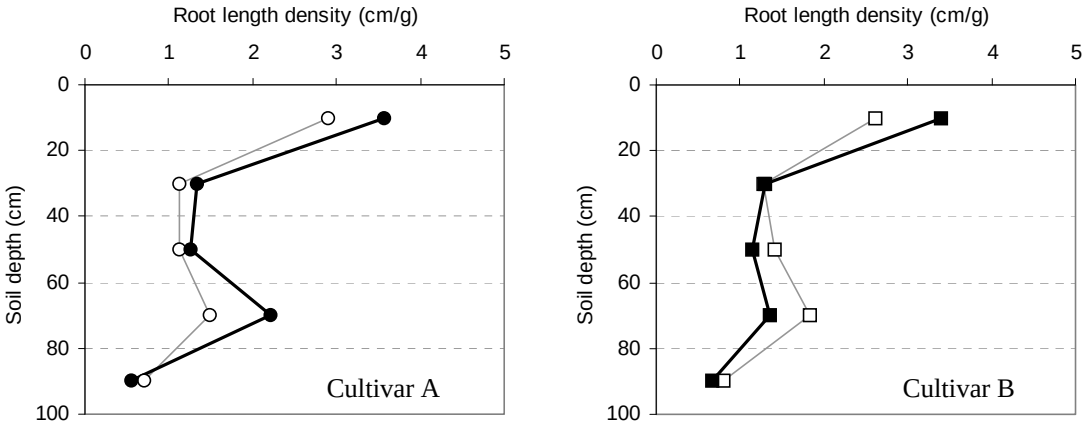

Figure 1. Root length densities of two winter wheat cultivars in cm root g^{-1} soil in the soil profile. Plants were either non-stressed (filled symbols, black line) or water-stressed (open symbols, grey line).

Cultivars differed significantly in overall root lengths produced, and water-stressed plants tended to produce less overall root length. Cultivars did however not respond differently in their root production in response to water stress.

Data for root production and distribution presented here are from only one growing season. Additional data will be necessary to determine whether the examined cultivars differ in the distribution of their roots in the soil profile in response to water stress. Especially the ability to produce roots in deeper soil layers could markedly improve cultivar drought tolerance (Manschadi et al., 2006).

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