Growth and water use response of two wheat cultivars exposed to water deficit at four growth stages

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Abstract

An understanding the plant physiological, genetic and biochemical mechanisms of drought tolerance is essential for crop improvement. The growth and water use responses of two wheat cultivars reputed to be high (cv. Hartog) and low (cv. Sunco) in osmotic adjustment capacity were examined under water deficit in pots in a growth room. Well-watered and water-deficit treatments were imposed at the young seedling, vegetative, reproductive, and grain filling stages. Cumu-lative transpiration, soil water extraction, total biomass, and leaf extension, relative water content, water potential and osmotic potential were compared under well-watered and water-deficit conditions. Leaf extension at the vegetative stage differed significantly across cultivar by water regime with time after withholding water, and total biomass differed significantly across cultivar by water regime. In water-deficit, cumulative transpiration increased towards a maximum related to the plant available water capacity in the pot, while it continued to increase exponentially in well-watered. From Time Domain Reflectometry at the reproductive stage, the upper and lower limits of plant-available soil water were 9% and 2% in this soil, and Hartog extracted more water than Sunco. Generally, in water-deficit, leaf relative water content was significantly lower, and leaf water potential and osmotic potential were more negative than those in well-watered. This research is part of a PhD study which seeks a better understanding of osmotic responses of wheat to water deficit, and the implications for adaptation and crop improvement.

Keywords

soil water extraction, water availability

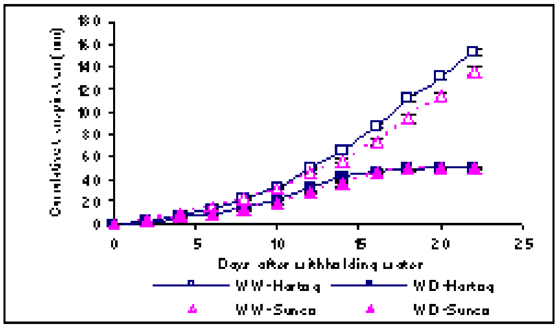
Introduction

Water deficit is common in dryland wheat farming, and is the major abiotic stress limiting crop productivity in Australia (Morgan 2001). Therefore, understanding the physiological, genetic and biochemical mechanisms of drought stress tolerance is required for crop improvement (Sharp et al. 2004). This study evaluated the growth and water use responses of two wheat cultivars reputed to be high and low in osmotic adjustment (OA) capacity, at the young seedling, vegetative, reproductive, and grain filling stages.

Method

The experiment was carried out in a growth room at UWA (21/16^{o}C, 10h d/14h n) using two cultivars reported to be high (cv. Hartog) and low (cv. Sunco) in OA capacity (Morgan 2001). A split-plot design was used, with two water regimes (well-watered and water deficit) as main plots and two cultivars as subplots. The water availability treatments were imposed at young seedling (7x7x5 cm^3 pot with 160 g soil), vegetative (10 cm diameter and 50 cm height pot with 6 kg soil), reproductive and grain filling (15 cm diameter and 80 cm height pot with 23 kg soil) stages. The soil was air-dried sand and 10% coarse river sand mixed with fertilizer. The soil surface was covered with gravel.

Results and Discussion



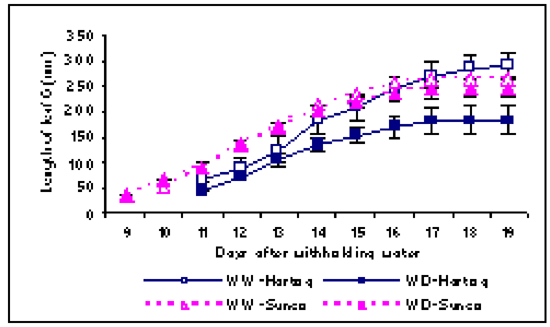
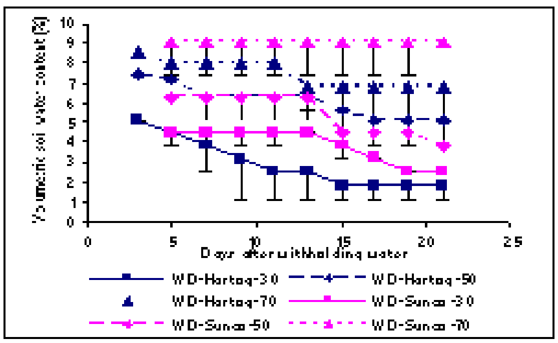


Fig.1. Cumulative transpiration (mean?SE;n=3) measured by weighing pots at the vegetative stage. WW:well-watered, WD:water-deficit

Fig.2. Leaf 6 extension (mean?SE;n=3) at the the vegetative stage



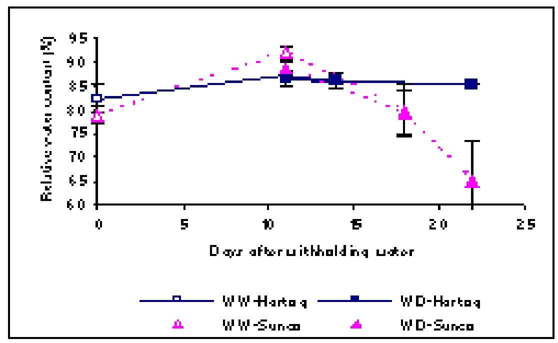


Fig.3. The pattern of soil water extraction measured using TDR under WD at the reproductive stage (at n=3) 30, 50 and 70 cm soil layer)

Fig.4. Leaf relative water content (mean?SE; at the reproductive stage during 22 days after withholding water

Cumulative transpiration increased exponentially in well-watered (WW), while it fell behind and

increased to a plateau in water deficit/WD, though more quickly in Hartog (Fig.1). This resulted in significant differences in total biomass (data not shown) and leaf extension (Fig.2) across cultivar by water regime. Time Domain Reflectometry (TDR) showed that soil water extraction at the reproductive stage was more rapid and to a greater extent at 30 cm than at 50 and 70 cm depths in the soil column (Fig.3.), and Hartog extracted more water than Sunco (2% at 70 cm depth). In WD, leaf relative water content of Hartog (85%) was higher than that of Sunco (65%) at 22 days after withholding water (Fig.4). Accumulation of inorganic and organic solutes is being examined on leaf samples taken from these experiments.

Conclusions

The cultivar Hartog, which is reputed to have stronger capacity for osmotic adjustment, did extract more water and maintained leaf relative water content for longer as water stress progressed. Data on inorganic and organic solutes are needed to examine this further.

References

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