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ScienceDirect
Journal of Integrative Agriculture
2014, 13(5): 975-989
May 2014
RESEARCH ARTICLE

The Relative Contribution of Non-Foliar Organs of Cotton to Yield and Related Physiological Characteristics Under Water Deficit

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Abstract

Water deficit is one of the most important causes of decreased yield in cultivated plants. Non-foliar green organs in cotton play an important role in yield formation at the late growth stage. Although better photosynthetic performance was observed in a non-foliar organ (bract) compared with leaves under water deficit. However, the physiological response of each organ in cotton to water deficit has not been comprehensively studied in relation to the water status and photosynthesis characteristics. We studied the maintenance of water status of each organ in cotton by measuring their relative water content, proline content and stomatal characteristics. Water deficit significantly decreased the surface area of each organ, but to a lesser extent in non-foliar organs. Our results showed that the relative contribution of biomass accumulation of non-foliar organs increased under water deficit. Non-foliar organs (bracts and capsule wall) showed less ontogenetic decrease in O_2 evolution capacity and in RuBPC activity (per dry weight) as well as better antioxidant systems than leaves at various days after anthesis. We conclude that the photosynthesis from non-foliar organs is important for increasing cotton yield especially under water deficit conditions.

Key words: non-foliar organ, water deficit, water status, antioxidant systems, biomass accumulation, cotton

INTRODUCTION

Drought is considered to be the main environmental factor limiting plant growth and yield worldwide, especially in semi-arid areas (Boyer 1982). It is well known that one of the primary physiological targets of water deficit is photosynthesis (Chaves 1991; Cornic 1994; Lawlor 1995). In cotton, drought significantly decreased leaf photosynthetic rate, but the green non-foliar organs (bracts) were not affected to the same extent as leaves (Wullschleger *et al*. 1990). Under water deficit, when photosynthesis in leaves is largely depressed, ear photosynthesis may be the main photosynthetic contributor to grain filling in wheat (Evans *et al*. 1972; Bort *et al*. 1994; Sánchez-Díaz *et al*. 2002).

Compared to the flag leaf, the photosynthetic parts of the ear in wheat have physiological and morphological traits that may confer resistance to water deficit (Morgan 1980; Blum 1985; Knoppik *et al*. 1986; Xu and Ishii 1990; Araus *et al*. 1993; Bort *et al*. 1994). Under water deficit conditions, the ability to maintain cell water status is essential for continued growth. Compared with that of the subtending leaf and bracts, the water status in cotton fruit is less sensitive to drought (van Iersel and Oosterhuis 1996). Drought also causes a series of alterations in biochemical processes related to photosynthesis.

Received 25 February, 2013 Accepted 16 July, 2013
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doi: 10.1016/S2095-3119(13)60568-7

In chloroplasts, for example, water deficit induces generation of active oxygen species (AOS) (Asada 1999). The AOS trigger deleterious reactions that involve degradation of proteins, enzyme inactivation, pigment bleaching and membrane injury (Asada and Takahashi 1987; Virgin *et al*. 1991; Irigoyen *et al*. 1992; Metha *et al*. 1992). To prevent oxidative damage, plants have evolved a complex antioxidant defence system, such as superoxide dismutase (SOD), asocrbate peroxidase (APX), glutathione reductase (GR), glutathione, ascorbic acid, and carotenoids (Car) (Liebler *et al*. 1986; Elstner 1987; Larson 1988). However, there have been few studies of the photosynthetic characteristics of non-foliar organs in response to water deficit. Compared with leaves, studies examining the effects of water deficit on antioxidant systems in non-foliar organs are few, despite the importance of antioxidant defence systems in helping chloroplasts to ameliorate oxidative stress and the fact that oxidative stress strongly affects photosynthetic capacity.

The objective of the present study was to investigate different physiological processes of leaf and non-foliar organs in response to water deficit. In this context, relative water content (RWC), proline content and stomatal characteristics were determined in various green organs in cotton under drought. In order to reveal their different capacities to resist drought, we also compared the photosynthetic rate, lipid peroxidation, RuBPC activity, soluble protein as well as antioxidant systems of leaves and non-foliar organs of cotton grown under both well-watered conditions and water-deficit stress. Also, the photosynthetic role of non-foliar organs to contribution to yield formation under drought was examined. Understanding the physiological photosynthetic responses of each green organ to drought is essential for a holistic elucidation of the resistance of cotton to drought.

RESULTS

Relative water content and stomatal charactertics in response to water deficit

The RWC is the most commonly used water status parameter to assess the degree of water deficit. Drought induced a larger decrease in RWC of the main stem compared with that of the other organs during the growth stages. Under water deficit, the reduction of RWC in leaf and main stem, at 20 day after anthesis (DAA), was 16.7 and 18.2%, respectively. The RWC of the bract was significantly lower than those in the other organs both under well-watered and water-deficit stress conditions. However, there was less decrease (10.04%) in RWC of bracts than in leaves. The RWC in capsule wall showed the least reduction (only 3.37%) among the green organs under water-deficit stress compared with well-watered conditions throughout growth stages (Fig. 1).

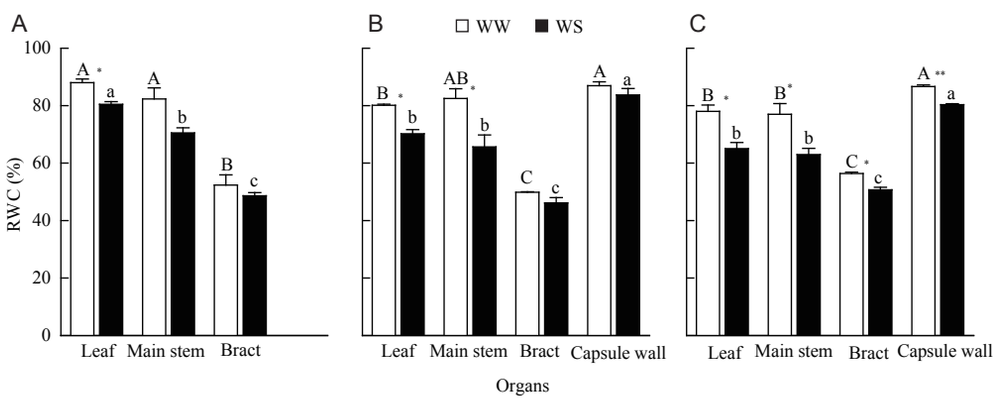

Fig. 1 Relative water content (RWC) of leaf, main stem, bract, and capsule wall of well-watered (WW) and water-deficit stress (WS) plants of cotton grown in field at 5 day after anthesis (DAA) (A), 15 DAA (B) and 20 DAA (C). Each value represents the mean±SD of three measurements. The same as below. Different letters denote significant differences among four green organs under WW (uppercase letters) and WS conditions (lowercase letters). Significant differences between two different water treatments: $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$. The same as below.

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