Effects of Potassium Deficiency on Ascorbate-Glutathione Cycle Related to Leaf Senescence in Cotton

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Introduction

• Premature senescence of cotton caused by K deficiency was initially reported in Alabama (Abaye, 1996), and then was reported in other countries, such as Australia (Wright, 1998) and China (Zheng and Dai, 2000).

• The antioxidant mechanism contains two important antioxidant protection systems (protecting enzyme system and ascorbate (ASC) – glutathione cycle) to avoid the deleterious effect of ROS (Djanaguiraman et al., 2009).

• Low-K-tolerant and low-K-sensitive cotton cultivars were screened in pot and field experiments according to yield, fiber quality and K^+ assimilation (Zhang et al., 2007; Yang et al., 2014). The cultivars with different K sensitivities had different K efficiencies.

Hypothesis

K deficiency will accelerate senescence of cotton, and shorten the functional stage of cotton leaf by damaging the antioxidant mechanism (ASC–glutathione cycle).

Objectives

- Explore the influences of K deficiency on cotton ageing process, such as flowering period.
- Investigate the effects of K deficiency on aging process of cotton leaf, the contents of H_2O_2 and malondialdehyde (MDA).
- Investigate the changes in the ASC–glutathione cycle in cotton leaf under K deficiency.

Materials & Methods

- **Experiment design**
  - Conducted at the Pailou experimental station of Nanjing Agricultural University, located at Nanjing, China (118◦50'E, 32◦02'N)
  - Planted late April 2012 and 2013
  - Furrow irrigated
  - Treatment
    - Two cultivars
      - Simian 3, low-K tolerant
      - Siza 3, low-K sensitive
    - Two K treatment
      - 0 kg K_2O ha^{-1}
      - 150 kg K_2O ha^{-1}
    - Randomized complete block design with three replications
- **Sampling**
  - Subtending leaves at the first fruiting position on the 7–8th sympodial fruiting branches.
  - 31 days after anthesis.
  - At 9:00–10:00 A.M.
  - 4-5 leaves.

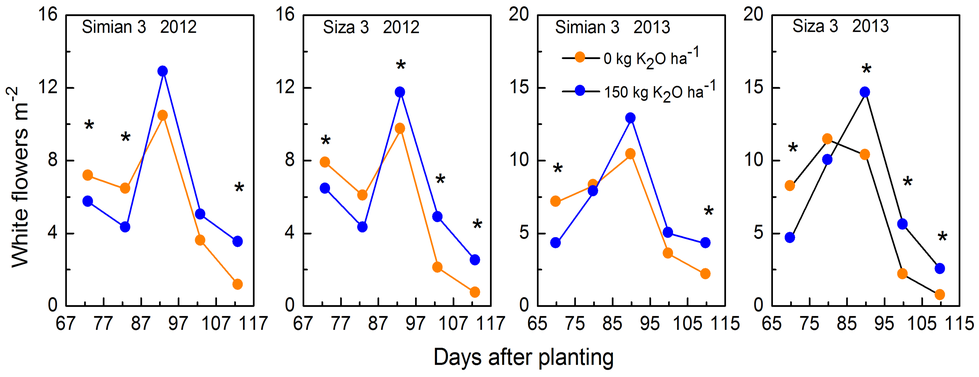

Figure 1: Changes of white blooms number at various time in 2012 and 2013 under K deficiency.

Results

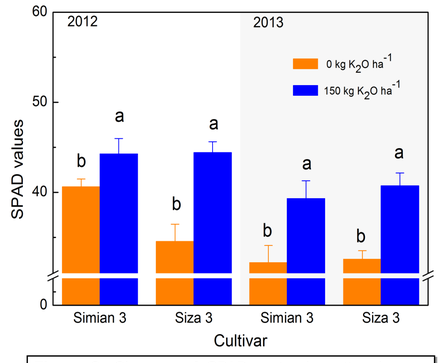

Figure 2: Changes of SPAD meter in cotton leaves. Different letters indicate significant differences (p = 0.05).

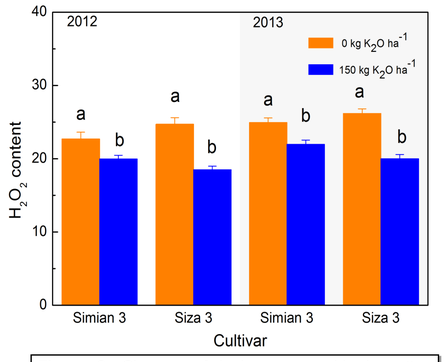

Figure 3: Changes of hydrogen peroxide in cotton leaves. Different letters indicate significant differences (p = 0.05).

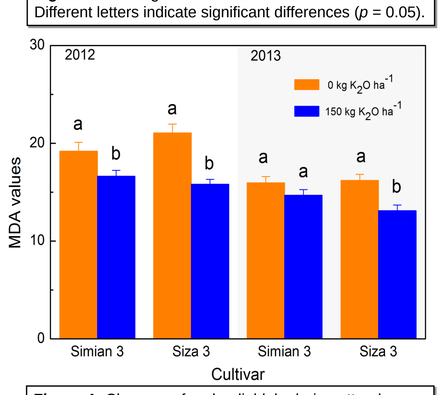

Figure 4: Changes of malondialdehyde in cotton leaves. Different letters indicate significant differences (p = 0.05).

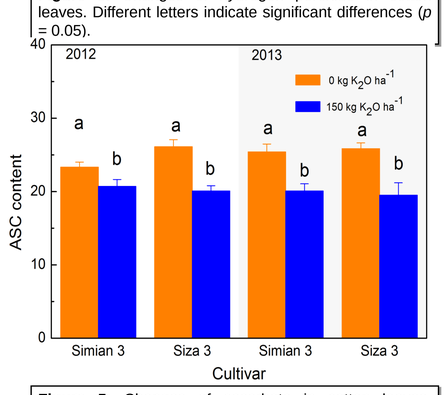

Figure 5: Changes of ascorbate in cotton leaves. Different letters indicate significant differences (p = 0.05).

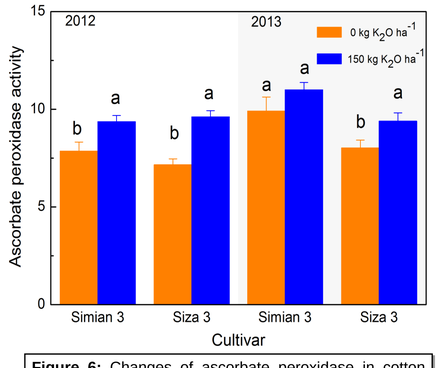

Figure 6: Changes of ascorbate peroxidase in cotton leaves. Different letters indicate significant differences (p = 0.05).

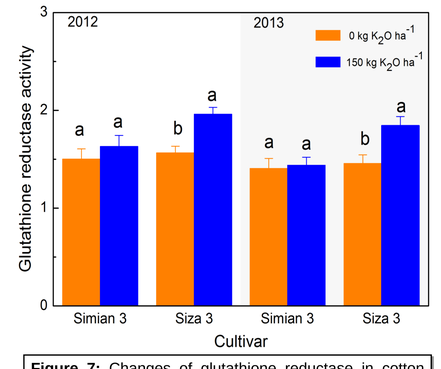

Figure 7: Changes of glutathione reductase in cotton leaves. Different letters indicate significant differences (p = 0.05).

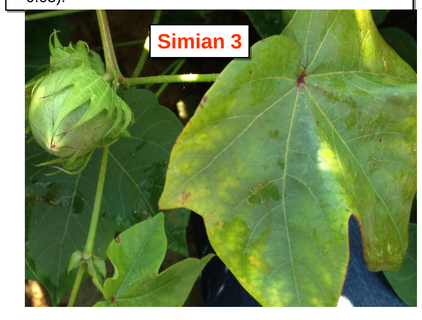

Figure 8: Symptoms of K deficiency for different cotton cultivars (Simian 3 and Siza 3).

Discussion

Figure 1:

• White bloom numbers per unit area were higher in the 0 kg K_2O ha^{-1} treatment before 90 or so days after planting, then became lower.

Figure 2:
• K deficiency could accelerate the chlorophyll degradation estimated by SPAD meter.

Figure 3 and Figure 4 :
• H_2O_2 content was obviously increased under K deficiency, resulting in an increase in MDA concentration.
• For Siza 3, Increased amplitudes of H_2O_2 and MDA contents were bigger under K deficiency.

Figure 5:
• Lower H_2O_2 content and lower MDA content indicated less eroxidative damage in the 150 kg K_2O ha^{-1} treatment, because ASC reduced H_2O_2 attack. Thus, lower ASC content was found under K application.

Figure 6:
• Ascorbate peroxidase activity was lower in the 0 kg K_2O ha^{-1} treatment than 150 kg K_2O ha^{-1} treatment, suggesting that the reaction between ASC and H_2O_2 was restricted.

Figure 7:
• Glutathione reductase activity was little changed in Simian 3, but was markedly reduced in Siza 3 in the 0 kg K_2O ha^{-1} treatment, indicating that the reduction reaction of GSSG to GSH under K deficiency was restricted in Siza 3.

Conclusions

- **The effects of K deficiency on cotton :**
  - Early season flowering rate
  - Early chlorophyll degradation
  - Higher H_2O_2 and MDA contents
  - Higher ASC content
  - Lower ascorbate peroxidase activity
  - Lower glutathione reductase activity
- **The differences between the two cultivars in response to K deficiency:**
  - For Siza 3, Increased amplitudes of H_2O_2 and MDA contents were bigger under K deficiency.
  - Glutathione reductase activity was more sensitive in Siza 3 than Simian 3 to low-K

Literature Cited

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