

# Mechanism Involved in Carbon and Nitrogen Metabolism underlying the Genetic Variation in the Tolerance to Potassium Deficiency in Cotton (*Gossypium hirsutum*) Seedlings



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## Introduction

Bt-transgenic cotton production has increased rapidly due to its resistance to bollworm and other benefits to growers (Huang et al., 2003). However, compared with conventional cotton cultivars, Bt-transgenic cotton cultivars were more susceptible to premature senescence caused by potassium deficiency (Tian et al. 2008). This study was carried out to investigate the mechanisms that contribute to different tolerance to K deficiency between Bt-cotton and conventional cotton with a focus on carbon and nitrogen metabolism.

## Materials and methods

The experiments were conducted in a growth chamber with 28/20 °C, 14/10 h day/night, and 450 μmol m<sup>-2</sup> s<sup>-1</sup> photon flux density. Bt- cotton cultivar, 'NuCOTN99<sup>B</sup>', and conventional cotton cultivar, 'liaomian18', were used as materials. Seeds of cotton were pre-germinated in sand and seedlings were individually transplanted into pots filled with a modified Hoagland solution, plus KCl as desired for low K treatment (K1) of 0.03 mM and high K treatment (K2) of 2.5 mM.

## Result

The dry matter accumulation in shoots and roots was significantly reduced by K deprivation (Fig. 1). This could partly be explained by:

1) Decreased concentrations of total chlorophyll (Table 1), Rubisco activity (Table 2) and RuBP regeneration (not show) which lead to low photosynthetic CO<sub>2</sub> fixation rate (Table 2);

2) Significantly decreased the activity of NR and GS in 'NuCOTN99<sup>B</sup>', while the GS in 'liaomian18' did not changed (Table 3).

3) Limited photoassimilate production and N metabolism coupled with transport inhibition can lead to sugar (Fig.2) and amino acids (Fig.3) concentration significantly higher in leaf;

4) K deficiency decreased the export rate of sugar, amino acids from the leaf to other parts, so, the export rate of carbon / amino acids also changed (Fig.3).

## Discussion

The high carbon / amino acids ratio represses photosynthetic activity (Wingler et al. 2006) and induces leaf senescence (Araya et al. 2010). On the other hand, 'liaomian18' had lower carbon / amino acids ratio, the

photosynthetic activity of the leaves is maintained, and senescence of the leaves is repressed (Araya et al. 2010). Plant architecture is controlled by a variety of signals originating from primary carbon and nitrogen metabolism (Kruse J et al. 2010).

## Conclusion

Less production and export of photo assimilates in 'NuCOTN99<sup>B</sup>' probably explain its lower tolerance to low-K.

Table 1. Effects of K deficiency on chlorophyll concentration in the youngest fully-expanded leaf of cotton seedling (26 days after treatment).

Treatment	K	C <sub>chl</sub> a.		C <sub>chl</sub> b.		total C <sub>chl</sub>	Chlorophyll
		(g·m <sup>-2</sup> ·FW <sup>-1</sup> )	(g·m <sup>-2</sup> ·FW <sup>-1</sup> )	(g·m <sup>-2</sup> ·FW <sup>-1</sup> )	a/b.		
'liaomian18'	K1.	0.47 b.	0.17 c.	0.64 c.	2.77 b.		
	K2.	0.91 a.	0.44 b.	1.35 b.	2.08 c.		
'NuCOTN99 <sup>B</sup> '	K1.	0.34 c.	0.11 c.	0.45 d.	3.08 a.		
	K2.	0.95 a.	0.65 a.	1.60 a.	1.47 d.		

Table 2. Effects of K on net photosynthesis rate (P<sub>n</sub>), Rubisco activity, stomatal conductance, intercellular CO<sub>2</sub> concentration (C<sub>i</sub>) in the youngest fully-expanded leaf of cotton seedling (26 days after treatment).

Treatment	K	P <sub>n</sub>	Rubisco activity	stomatal conductance	C <sub>i</sub>
		(μmol CO <sub>2</sub> ·m <sup>-2</sup> ·s <sup>-1</sup> )	(μmol·m <sup>-2</sup> ·s <sup>-1</sup> ·FW <sup>-1</sup> )	(μmol H <sub>2</sub> O·m <sup>-2</sup> ·s <sup>-1</sup> )	(μmol CO <sub>2</sub> ·mol <sup>-1</sup> )
'liaomian18'	K1.	6.54 b.	2.435 c.	32.33 c.	390.75 ab.
	K2.	14.23 ab.	3.819 b.	175.22 b.	327.41 b.
'NuCOTN99 <sup>B</sup> '	K1.	5.45 c.	1.485 c.	38.36 c.	421.33 a.
	K2.	16.88 ab.	4.976 a.	241.33 ab.	325.33 b.

Table 3. Effects of K on protein concentration, nitrate reductase (NR), and glutamine synthetase (GS) activity in the youngest fully-expanded leaf of cotton seedling (26 days after treatment).

Treatments	K	concentration of protein	NR activity	GS activity
		(g·m <sup>-2</sup> ·FW <sup>-1</sup> )	(mg·h <sup>-1</sup> ·m <sup>-2</sup> ·FW <sup>-1</sup> )	(A·mg <sup>-1</sup> ·h <sup>-1</sup> ·FW <sup>-1</sup> )
'liaomian18'	K1.	2.683 c.	2.567 d.	32.305 ab.
	K2.	4.921 a.	5.331 b.	26.998 b.
'NuCOTN99 <sup>B</sup> '	K1.	3.512 b.	4.304 c.	35.897 a.
	K2.	3.504 b.	11.0122 a.	22.165 c.

Fig. 1 Effects of sufficient (K2) and deficient supply (K1) on dry matter in different parts of cotton at 26 DAY after the treatment.

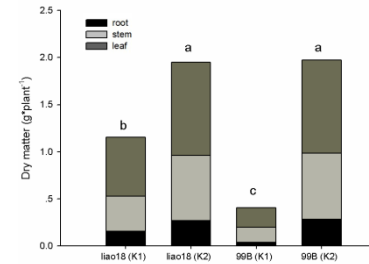


Fig. 2 Effects of sufficient (K2) and deficient supply (K1) of leaves and export of concentration of soluble sugar of cotton at 26 DAY after the treatment.

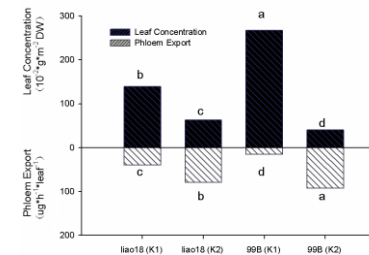


Fig.3. Effect of sufficient (K2) and deficient supply (K1) on the fourth youngest fully expanded leaves and on export of total amino acids of cotton over 26 DAY of growth in nutrient solutions.

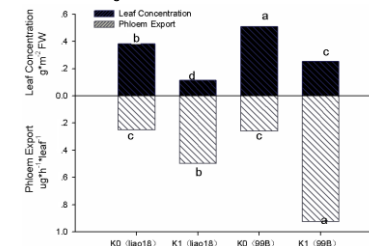
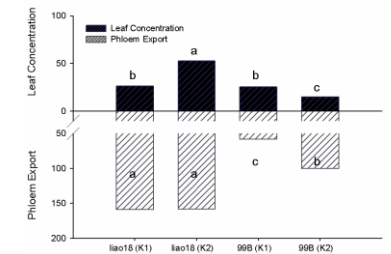


Fig.4. Effect of sufficient (K2) and deficient supply (K1) on the fourth youngest fully expanded leaves and on export of concentration of carbon / amino acids ratio of cotton over 26 DAY of growth in nutrient solutions



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