EFFECT OF WATER-DEFICIT STRESS DURING REPRODUCTIVE DEVELOPMENT ON POLYAMINE CONTENT OF COTTON FLOWERS

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Abstract

Polyamines, putrescine (PUT), spermidine (SPD), and spermine (SPM) are ubiquitous components of all living cells. Apart from their participation in numerous physiological and metabolical functions of the plant, they are also implicated in plants' responses under conditions of abiotic stress. Previous research in other crops has indicated that polyamines and changes in their concentrations are associated with drought tolerance under conditions of water deficit stress, however no information exist for cotton (*Gossypium hirsutum* L.). A field study was conducted in 2011 in two locations (Fayetteville, AR, and Lubbock, TX) in order to investigate the effect of water stress during flowering on polyamine metabolism of the cotton flower and its subtending leaf. Cotton cultivar ST5288B2F was planted in both locations and treatments consisted of control (well watered) and water-stress (irrigation was withheld for two weeks at the onset of flowering). First position white flowers and their subtending leaves were collected at the end of each week and used to determine polyamine concentrations. PUT and SPD levels of water-stressed pistils and leaves were significantly higher compared to the control. Pistil and leaf SPM content significantly increased under drought conditions in one location, remaining unaltered in the other one. Growth chamber experiments were also conducted in 2011-2012, with two cotton cultivars differing in drought tolerance, ST5288B2F (average drought-tolerant) and Siokra L23 (drought-tolerant). According to our results cotton ovaries contained significantly higher levels of total polyamines compared to their subtending leaves under both control and water stress conditions. Water-deficit stress significantly increased PUT concentrations in ST5288B2F, while SPM levels significantly decreased in Siokra L23. The results indicated that water-deficit stress significantly affected cotton polyamine metabolism in reproductive structures and their subtending leaves, however no clear relationship between drought-tolerance and changes in polyamine accumulation was established.

Introduction

Polyamines are low molecular weight cationic polycations, with the main forms occurring in plants being the diamine, PUT and its derivatives, the triamine SPD and the tetramine SPM (Kao, 1997). They have been observed to participate in a variety of physiological and metabolic functions (Kaur-Shawnhey, 2003) while their presence is indispensable during flowering (Kakkar and Rai, 1993). Changes in polyamine concentrations have been reported to be a common plant response to a variety of abiotic stresses such as salinity and high or low temperatures, as well as drought (Bouchereau et al., 1999; Groppa and Benavides, 2008). Under conditions of water stress, polyamines function either as protective agents, similar to antioxidants (Smirnoff, 1993; Capell et al., 1998) or as signaling molecules due to their connection to abscisic acid (ABA) metabolism (Alcazar et al., 2006). Increased polyamine concentrations have been associated with enhanced drought-tolerance (Capell et al., 1998), however, variable responses have been observed in different crops under conditions of water-deficit stress. Despite the extensive research in other crops, little information exists for cotton.

Materials and Methods

Growth chamber studies were conducted in 2010-2011 in Fayetteville, AR. Cotton (*Gossypium hirsutum* L.) cultivars ST5288B2F (drought-sensitive) and Siokra L23 (drought-tolerant) were planted into 2L pots containing a horticultural mix (Sun-Gro Horticulture, Canada Ltd.). The growth chambers were set for normal conditions of 32/24°C (day/night), ±60% RH, and 14/10h photoperiod and half-strength Hoagland's nutrient solution was applied daily in order to maintain adequate nutrients and water. At flowering plants were randomly divided into: (1) control (optimum quantity of water), and (2) water-stress (50% of daily use quantity of water) treatments. The experimental design was a 2x2 factorial design (water-regime x cultivar) with 15 replications. Field studies were also conducted in 2011 in Fayetteville, AR, and Lubbock, TX. Cotton cultivar ST5288B2F was planted in both locations in a split block design arrangement. Treatments consisted of: untreated control (no water-deficit stress), and water-deficit stress at the flowering stage. White flowers and their subtending leaves were sampled at noon for polyamine analysis.

Results

Cotton ovaries were observed to contain higher concentrations of total polyamines under normal and water-stressed conditions compared to the leaves (Table 1). Water-deficit stress significantly increased putrescine and spermidine content in both leaf and ovary, while spermine content remained unaffected in either tissue (Table 2). Drought-sensitive ST 5288 increased total polyamine content under water stress, while drought-tolerant Siokra L23 showed no significant response leading us to speculate that stress was not severe or long enough to induce polyamine accumulation (Table 3). Polyamine metabolism is significantly affected by water-deficit stress and polyamine changes could be used as indicators for selection of drought tolerant cultivars.

Table 1: Effect of water-deficit stress on total leaf and ovary polyamine content of cotton cultivars ST5288B2F (ST5288) and SiokraL23 (Siokra). Levels with different letters are significantly different (P=0.05).

Cultivar	ST5288		Siokra	
Total PAs	**Leaf**	**Ovary**	**Leaf**	**Ovary**
Control	c	b	b	a
Water stress	c	a	b	a

Table 2: Effect of water-deficit stress on leaf and ovary putrescine, spermidine and spermine content in cotton under field conditions (C: Control, WS: Water-stress). Levels with different letters are significantly different (P=0.05).

Polyamine	Putrescine				Spermidine				Spermine			
Tissue	**Leaf**		**Ovary**		**Leaf**		**Ovary**		**Leaf**		**Ovary**	
Treatment	**C**	**WS**	**C**	**WS**	**C**	**WS**	**C**	**WS**	**C**	**WS**	**C**	**WS**
	b	a	b	a	b	a	b	a	a	a	a	a

Table 3: Effect of water-deficit stress on leaf and ovary putrescine, spermidine and content of cotton cultivars ST5288B27 (ST) and SiokraL23 (Siokra) (C: Control, WS: Water-stress). Levels with different letters are significantly different (P=0.05).

	Putrescine				Spermidine				Spermine			
Cultivar	**LEAF**		**OVARY**		**LEAF**		**OVARY**		**LEAF**		**OVARY**	
Tissue	**ST**	**Siokra**	**ST**	**Siokra**	**ST**	**Siokra**	**ST**	**Siokra**	**ST**	**Siokra**	**ST**	**Siokra**
C	b	a	b	b	a	a	a	b	ab	ab	a	a
WS	a	a	a	b	a	a	ab	b	a	b	a	b

Summary

Water-deficit is considered to be a major abiotic factor responsible for plant growth compromise and severe yield decreases. Polyamine metabolism was shown to be significantly affected by water-deficit stress and polyamine changes. Further research of the polyamine metabolism of cotton's reproductive units under conditions of water stress would provide valuable insight for genotypic selection of drought tolerant cultivars and formulation of plant growth regulators. Additionally, future research should explore possible relationships between known drought tolerance traits and polyamines in a larger range of cotton germplasm.

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