Genetic Variations in Leaf Growth Rate in Tall Fescue in Association with Differential Gene Expression Controlling Cell Elongation

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Introduction

Cell expansion is controlled by cell extensibility, which is regulated by expansin and xyloglucan endotransglycosylase (XET) proteins. The expression of expansin and XET has been associated with cell elongation controlling leaf, stem, and root elongation in various plant species. However, limited information is available on the genetic variations associated with differential leaf elongation rates in perennial grass, such as tall fescue.

Drought stress inhibits plant growth through influencing leaf initiation and elongation. Mild drought can reduce rate of leaf expansion and final leaf size. Severe drought stresses generally decrease leaf elongation rate and leaf growth can cease. However, the effects of drought stress on leaf elongation in tall fescue and the genes controlling the elongating processes under drought stress are not well known.

Objectives

Examine genetic variations in expansin and XET genes expression in leaves in fast growing vs. slow growing (dwarf) tall fescues in order to identify specific genes controlling leaf elongation.

Materials and Methods

Plant Materials

Tall fescue – 'Bonsai' (slow growing) vs. 'K-31' (fast growing)

Growing Conditions

- Seeds of both cultivars were sown in 50-cell plastic trays.
- Plants were watered every other day and fertilized with half-strength nutrient solution twice a week when the first leaf appears.
- After seedling emergence for 2 weeks, uniform-sized seedlings will be transferred into plastic containers filled with half-strength nutrient solution. The solution in each container will be aerated using an aquarium pump.
- 20 uniform-sized seedlings will be transplanted into each container in four containers for each cultivar.
- Growth chamber conditions: 22/18° C, 650 PAR, 60% RH
- Drought Stress : -0.5mpa, -1mpa, -1.5mpa
- All treatments were performed in 4 replicates

Hydroponic System

Physiological Criteria

Leaf elongation Rate (mm/d)
Epidermal cell length
Leaf Relative Water Content (RWC)

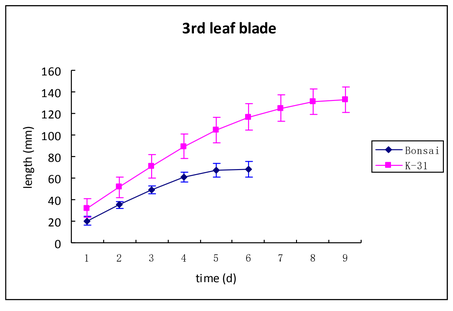
Gene Expression Analysis

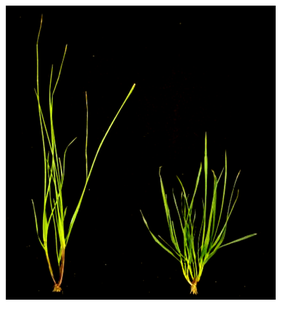
5 expansin genes (*A1*,*A5*,*A9*,*B2*,*B11*) and 3 XET (*XET1*,*XET2*,*XET3*) genes were tested by quantitative RT-PCR

Statistic Analysis

Treatment effects by ANOVA using SAS 9.2
LSD means tested at P<0.05 level

Fig. 1 The 3rd leaf length of both cultivars during the growth period after its emergence from the 2nd leaf whorl

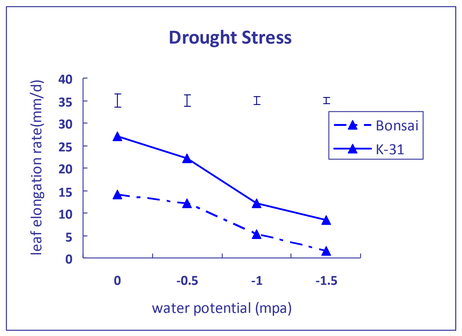




Two tall fescue cultivars show different growth rates : the fast growing cultivar 'K-31' is 18 mm/d, slow growing cultivar 'Bonsai' is (13 mm/d).

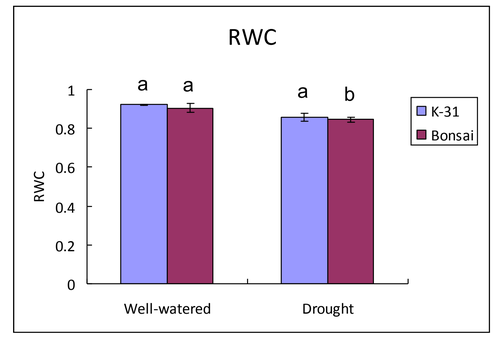
Results and Discussion

Fig. 2 Leaf elongation rate (LER) of both cultivars under well-watered and drought conditions



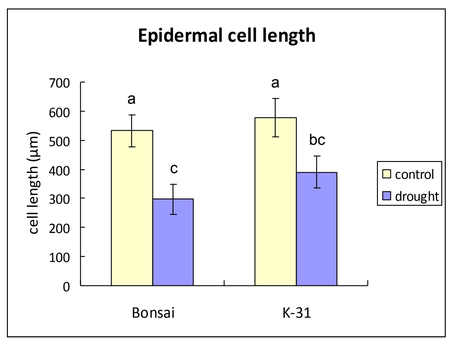
Drought stress inhibited the leaf elongation rate of both cultivars. 'K-31' showed higher elongation rate than 'Bonsai' both under well-watered and drought conditions.

Fig. 3 Relative Water Content of both cultivars under well-watered and drought conditions



Drought stress reduced the leaf RWC of leaves in both cultivars.
'K-31' had higher RWC than 'Bonsai' under drought stress.

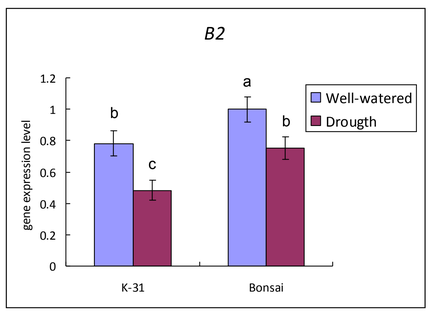
Fig. 4 Epidermal cell length of both cultivars under well-watered and drought conditions

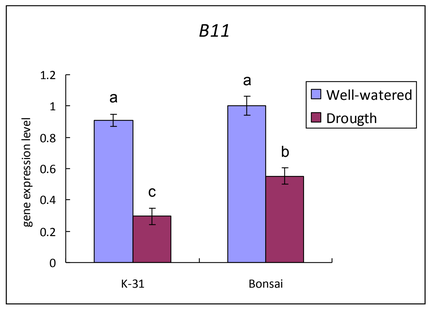


Drought stress inhibited the leaf epidermal cell elongation rate. But there were no differences in elongated cell length between two cultivars.

Fig. 6 Gene expression level of genetic drought stress-related expansins and XETs

Four expansin genes (A1,A9, B2 and B11) and one XET gene (XET2) were down-regulated by drought stresses, in which A9 was show different expression level between two tall fescues.
A9 may play an important role in grass leaf elongation.





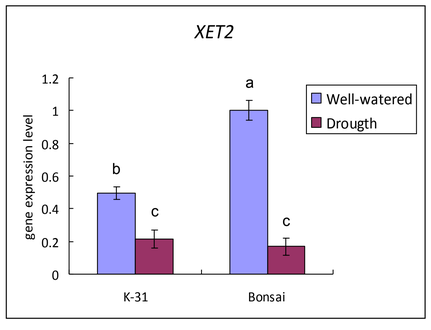
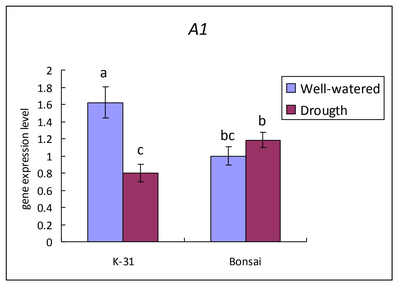
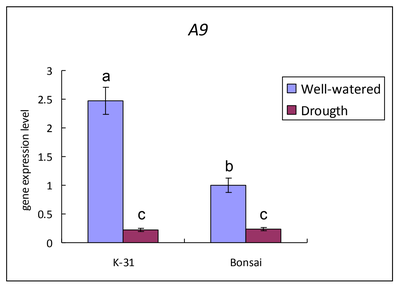


Fig. 5 Gene expression level of genetic variation-related genes





Two expansin genes, A1 and A9, were more expressed in fast growing cultivar 'K-31' than slow growing cultivar 'Bonsai' under well-watered condition.

Conclusions

Two tall fescue cultivars show different growth rates : the fast growing cultivar 'K-31' is 18 mm/d, as 1.5 times as the slow growing cultivar 'Bonsai'(13 mm/d).
The epidermal cell length of fast growing cultivar'K-31' is longer than that of slow growing cultivar 'Bonsai'.
Two expansin genes, *A1* and *A9*, are more expressed in fast growing cultivar 'K-31' than slow growing cultivar 'Bonsai', which indicated they are correlated with the leaf elongation rate variation of the two tall fescues.
Drought stresses severely inhibited the epidermal cell elongation and leaf growth of both fast growing tall fescue 'K-31' and slow growing tall fescue 'Bonsai'.
Four expansin genes (*A1*,*A9*, *B2* and *B11*) and one XET gene (*XET2*) were down-regulated by drought stresses.