ABIOTIC STRESS RESPONSES IN *STIPA SIBIRICA* (L)

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ABSTRACT

Stipa sibirica (L) is one of important perennial grass species which belong to genus of Stipa, and family of Poaceae. It has early growth in spring and good quality for animal productivity and good adaptability in vast range of sever conditions in all over the country. Temperature and drought stress are among the two most important environmental factors influencing crop growth, development and yield processes. This study compares three stresses which as cold, drought and saline conditions. In vitro stress assays are commonly used to study the responses of plants to abiotic stress and to assess stress tolerance. Exposure of plants to a drought stress for 10 days significantly decreased the photochemical efficiency of PSII and the Fv/Fm values were almost 50% lower (0.41±0.01) compared with the control plants (0.81±0.01). During cold stress after 21 days Fv/Fm decreased to 0.40 ± 0.03. The results of this study demonstrated that Stipa sibirica (L) plants were better adapted to cold conditions than the drought conditions

KEY WORDS: Fv/Fm, PS II, drought, cold, salt

INTRODUCTION

Stipa sibirica (L) is one of important perennial grass species which belong to genus of Stipa, and family of Poaceae. It naturally grows in mountain steppe rangelands in the west and north of Mongolia. It is being used for grazing and hay production and consumed by livestock. *Stipa* is the most important genus in grasslands of the cool temperate semi-arid zones [1]. It has early growth in spring and good quality for animal productivity and good adaptability of sever conditions in Mongolia.

Abiotic stress limits crop productivity and plays a major role in determining the distribution of plant species across different types of environments [2]. Environmental stresses and its effects on plants in both natural and agricultural settings is a topic that is receiving increasing attention because of the climate change and temperature extremes, salinization of agricultural lands by irrigation. These stresses not only have an impact on current crop species, but they are also significant barriers to the introduction of crop plants into areas that are not currently being used for agriculture [3].

Several researchers have reported that temperature and drought stress are among the two most important environmental factors influencing crop growth, development and yield processes.

Many species are severely damaged by drought [4] or chilling [5], which affects their growth and development and can significantly restrict their spatial distribution and agricultural productivity [6].

In vitro stress assays are commonly used to study the responses of plants to abiotic stress and to assess stress tolerance.

The objective of this study was to identify physiological and morphological responses of *Stipa sibirica* (L) species to cold, drought and salinty stress in laboratory conditions.

MATERIALS AND METHODS

Plant material and growth conditions

The *Stipa sibirica* (L.), used in this study, seeds derived from the NART I cultivars. Seeds were grown at 24/20°C (70% humidity) in continuous fluorescent illumination (100–150 µmol photons m^{-2} s^{-1}) in soil irrigated with water. After 6 weeks the seedlings were transferred to the experimental growth conditions.

For cold stress 6 weeks old plant transferred to low (4°C) temperature under constant light during 21 days. Control plants remained at 24°C under constant light.

For some experiments, seeds were dehusked, surface-sterilized and germinated on Murashige and Skoog [7] gelrite (0.8% w/v) medium containing 1% sucrose and growth in plant chamber 16/8 h light/dark photoperiod (100-150 µmol photons m^{-2} s^{-1}) and a day/night temperature of 24/20°C.

For NaCl, KCl treatment, sterilized seeds of plant were plated on MS media containing 50, 100 mM NaCl and KCl according to Miki et al. [8]

For sorbital treatment, sterilized seeds of plant were plated on MS media containing 200 and 400 mM sorbital according to Kadota et al. [9]

The final germination percentages (GF) and the rate of germination were determined by the following formula Timson,1965 [10], respectively:

GF (%) = [a / *b*] Ч 100

Measurement of Photochemical efficiency

Photochemical efficiency was measured using portable Plant Efficiency Analyzer (Hansatech Instrument, Norfolk, UK) according to the method of Tovuu et al. [11] on 30-min dark-adapted leaves of *Stipa sibirica* (L) plants after various time intervals of treatment cold and drought stress. Five replications were maintained for each treatment and the experiment was repeated three times.

RESULTS

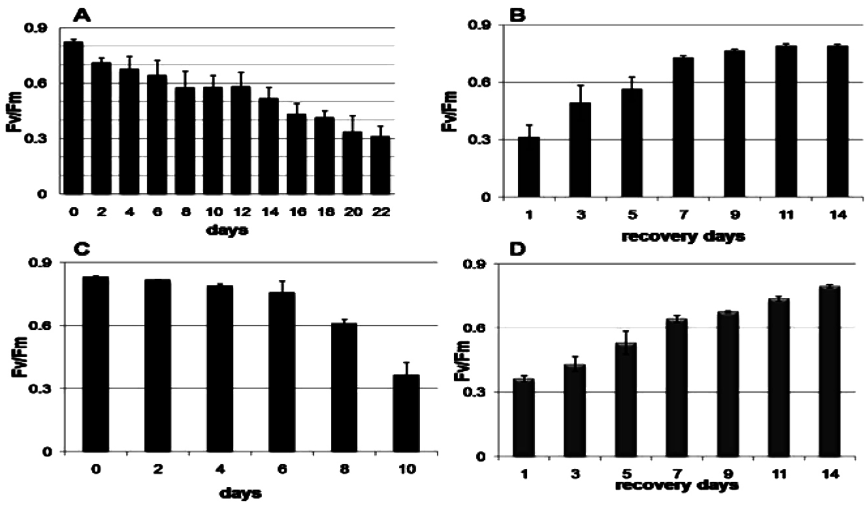
PSII is tolerance to low temperature in *Stipa sibirica (L)*

The photochemical efficiency (Fv/Fm) at normal growing conditions was 0.8 ± 0.01 for *Stipa sibirica* (L) plants. However, after low temperature treatment at 4°C for 5 days, Fv/Fm dropped to 0.67 ± 0.02 and Fv/Fm decreased to 0.62 ± 0.03 after 7 days and it was constantly until 14 days(Fig.1A). PSII in *Stipa sibirica* (L)was able to acclimate to long-term experiments.

After 21 days Fv/Fm decreased to 0.40 ± 0.03. At the 24°C Fv/Fm recovered further during the seventh day, and reaching, in the plant a value close to that measured before cold stress (Fig.1B)

PSII is sensitive to drought stress in *Stipa sibirica (L)*

Drought stress characterized by stopping irrigation (severe drought). At the beginning Fv/Fm did not change significantly and after 7 days Fv/Fm rapidly changed because it is due to less soil water depletion. Exposure of plants to a drought stress for 10 days significantly decreased the photochemical efficiency of PSII and the Fv/Fm values were almost 50% lower (0.41±0.01) compared with the control plants (0.81±0.01) (Fig.1C and D). The reduction in photochemical activities could be due to the disturbance or damages of photosynthetic apparatus (PS II) [12]. In vitro experiment also shows that *Stipa sibirica* (L) was no resistance at the drought conditions. With sorbitol treatments the germination rate was only 15-20% compared with control plants. (Fig.2). Greater reductions with sorbitol treatments were observed, and at 200 mM and 400 mM sorbitol there was no hypocotyls and root development.



Picture 1. The photochemical efficiency of PSII (Fv/Fm) in plants acclimated to cold (A,B) and drought (C,D) stress . Values are means ± SD (n=5).

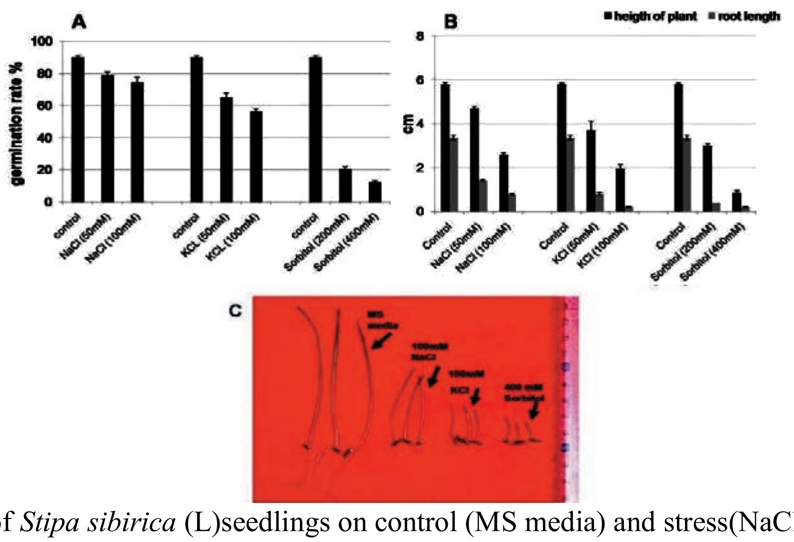
Effect of stage of salinity treatment application on plant growth

The response of germination to salinity stress varies with species and variety, salt type, salt concentration and environmental conditions. Eight salt treatments, 0, 25, 50 and 100 mM NaCl or KCl were applied and germination was carried out in petri dishes at 28°C for 10 days. Seed germination in control treatments from 90% in *Stipa sibirica* (L). With NaCl treatments the germination of plant was enhanced by 25 mM NaCl. Germination was progressively inhibited with increased NaCl concentrations. For example, at 50 mM NaCl the reduction in germination ranged from 20% and 74% of plants able to germinate at 100 mM NaCl.(Fig.2A).

With KCl treatments progressive decrease in germination at higher concentrations was observed. Exposure to 100 mM KCl depressed germination more than NaCl with germination reductions ranging from 44% in *Stipa sibirica* (L) (Fig.2A).

In *Stipa sibirica* (L) plant height and root length was significantly affected by salinity stress. Specially at the KCl more sensitive than NaCl. Plant height were significantly reduced with increasing concentrations of both NaCl and KCl were observed. At 100 mM NaCl and KCl reductions ranged from 5.7 to 2.5 and 1.9 cm compared with control plants.

The root length of control plant was 3,4 cm, whereas the decreased 0.8 and 0.21, cm when germinated them on MS supplemented with 100mM NaCl and KCl mediums, respectively. (Fig.2B and C) Hence, radicle elongation, and hypocotyl elongation both of them was more sensitive at higher salt concentrations.



Picture 2. Growth of *Stipa sibirica* (L)seedlings on control (MS media) and stress(NaCl, KCl, and sorbitol) treatment plates. (A) germination rate, (B,C) height of plant and root length . Values are means ± SD (n=5).

DISCUSSION

This study compares three stresses (cold, low water availability, and saline conditions).

The photosynthetic system in higher plants is highly susceptible to abiotic stresses under low temperatures, for instance, absorbed light energy cannot be used productively due to the inhibition of photosynthetic CO_2 assimilation and other metabolic processes [13]. Chlorophyll fluorescence parameters are direct indicators of the photosynthetic activity [14], [3] asserts that the decrease in photochemical activity under stress condition at vegetative stage was mainly. The Chl fluorescence parameter Fv/Fm represents the maximum activity of PSII and can be used to monitor PSII photoinhibition. This parameter describes the efficiency of electron transport inside PSII and has been shown to be linearly correlated with the quantum yield of light-limited O2 evolution and with the proportion of functional PSII reaction centers [15].

The capacity of the root system for rapid and early development is an important factor in drought resistance. It is well known that increased efficiency of moisture absorption is primarily due to the development of an extensive root system. Also, it is a common feature among the arid and semi-arid environment perennials that these plants develop root systems that are larger than their shoots. In the drought stress, *F*v/*F*m was significantly reduced than cold stress. An increase in drought resulted in the reduction of the root length and plants retained their radicle length compared with the control plants (Figure 2). The in vitro experiment results also showed that, treatment with sorbitol plants was significantly different from control plant. Drought, for instance, is simulated by adding osmotica, such as mannitol, sorbitol, or polyethylene glycol [2], which lower the water potential of the medium.

The reduction in Fv/Fm ratio was more severe under drought stress than under cold stress after 10 day of treatment. The combined cold and drought stresses caused more dramatic reductions in Fv/Fm than either cold or drought alone, starting at 14 and 7 days after treatment, respectively.

CONCLUITIONS

The results of this study demonstrated that Stipa sibirica (L) plants were better adapted to cold conditions than the drought conditions as they showed less visible symptoms, and highest Fv/Fm levels at the long time chilling stress.

At severe drought condition, plants exhibiting rapidly reduced photochemical efficiency. In vitro drought stress also shows that seed germinated only 20% compared with control plants. The reduction in photochemical activities could be due to the disturbance or damages of photosynthetic apparatus (PS II) [12].

Stipa sibirica (L) plants growth retardation under salt stress. Plant height, root length and dry matter weight of plant decreased when compared to control plants. According to our result of this experiment *Stipa sibirica (L)* was negatively affected by increasing salinity. Soil salinity should be controlled for when plant growing. NaCl and KCl compounds should be applied in a precise amount to *Stipa sibirica* (L).

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