S3-016

Studies on Photosynthetic Characteristics and Adaption to Environment of Some Alpine plants in Qinghai-Xizang Plateau

Z-P Zhong, K-B Wang, J-X Shan, L-J Feng, Y-Y Xin, L-B Li, T-Y Kuang

Institute of Botany, The Chinese Academy of Sciences, Beijing 100093, China
kuangty@ns.ibcas.ac.cn

Keywords: Alpine plants, Photosynthesis, Kinetics of Chl a fluorescence induction, 77K Fluorescence spectra, Carotenoids

Introduction

Photosynthesis of plants is subjected to influences of environmental factors, therefore the plant distributed to adverse ecosystem environment shows different photosynthetic adaptability. The ecosystem environment of alpine plants has a distinguishing feature of low temperature, strong radiation and low atmospheric pressure, consequently the photosynthetic characteristics of alpine plants distinguish from those of lowland plants (Lu et al. 1995). Qinghai-Xizang Plateau is a greatest plateau in the world, the high altitude causes its climate a remarkable change and makes morphology and physiology characteristics of plants adapting to plateau climate (Wang et al 1990). In recently years studies on photosynthetic property of some alpine plants have been reported, but those of some alpine plants in Qinghai-Xizang plateau are still absent. In addition, the investigation on the photosynthetic property of alpine plants only including gas exchange, pigment content and optimal temperature, have been described (Streb et al. 1998), but the efficiency of the conversion of light energy, photochemistry activity and the adaptive mechanism of photosynthesis have not been researched. In this study we compared the alpine plants and the same genera lowland plants in characteristic of chlorophyll fluorescence, photosynthetic pigment contents including xanthophylls cycle composition and the efficiency of the conversion light energy etc. for studying their photosynthetic characteristics and photosynthetic adaptability to high mountain environment.

Materials and methods

Investigations of alpine plants from Qinghai-Xizang Plateau were performed at September of the year 1998. Leaves of *Salix gilashanica* and *Salix pilosomicrophylla* were collected from hillside at about 3000m. Leaves of *Rhododendron coriaceum*, *Rhododendron faucium*, *Rhododendron nivale* were collected from alpine grasslands at about 3500-4000m. Leaves of *Quercus aquifolioides* from mixed forest of mountains at about 3000m.

For comparison fully expanded mature leaves of low-land plants at unshaded site at the Botanical Garden of Institute of Botany, The Chinese Academy of Sciences, Beijing, China (about 150m above sea level) were used. The low-elevation plant species *Salix babyleuica*, *Salix matsudana*, *Rhododendron maoronulatum*, and *Quercus liaotangensis* were selected from plant families corresponding to those of the alpine genera. The collected leaves was sealed in plastic bags kept at 0-5 degree Centigrade for physiological measurement in the laboratory.

The chloroplasts were isolated from the alpine plants and lowland plants. For the estimation of the fluorescence dynamic parameters, pulse-amplitude-modulation (PAM) fluorometer was used. The 77K fluorescence excitation and emission spectra of the chloroplasts were measured using Hitach F4500 fluorescence split-beam spectrophotometer. Chlorophyll and carotenoids concentration was determined in 96% ethanol (Lichtenthaler 1987). Extraction and quantification of the various carotenoids including xanthophyll cycle composition from the chloroplast was as described in Gilmore A.M (1997), using the high performance liquid chromatography procedure.

Result and discussion

Photosynthetic pigment contents

The data presented in table 1 indicated that the total chlorophyll and chlorophyll *b* content

Table 1 Comparison of chlorophyll and carotenoid contents of leaves from alpine and non alpine plant

Leaf	mg /g fresh W .T				
Species	Chl b	chl(a+b)	chla/b	car	car/chl
S.gilashanica	0.537	2.499	3.650	0.461	0.185
S.pilosomicrophylla	0.548	1.925	2.517	0.319	0.166
S.babylenica	0.620	2.517	3.066	0.383	0.152
S.matsudana	0.816	3.169	2.886	0.456	0.144
R.coriaceum	0.283	1.136	3.019	0.215	0.190
R.faucium	0.221	0.818	2.719	0.162	0.198
R.nivale	0.277	1.140	3.131	0.192	0.169
R.macronulatum	0.836	2.976	2.559	0.396	0.133
Q.aquifolioides	0.320	0.472	2.656	0.094	0.213
Q.liaotangensis	0.893	3.388	2.795	0.475	0.141

in alpine plants were lower than that in lowland plants. Ratio of chlorophyll *a*/*b* in alpine plants was higher than that in lowland plants. In addition, no significant difference was observed between the two series plants for the carotenoid but the carotenoid/chlorophyll ratio increased in alpine plants. The habitat of alpine plant are difference from that of lowland plant. The components of photosynthetic pigments of alpine plants have unique characteristics for strong radiation. In the strong radiation environment of high mountain light energy is easily captured and alpine plants decrease the chlorophylls in light-harvesting antennae of the photosynthetic organ. This leads to a essential decline in light absorption of their leaves and reduced photosynthetic organ damages caused by excess excitation energy (Wei et al 1998). The adaptation of some alpine plants to strong radiation appeared in the above results. Carotenoids constituents were compared in chloroplasts of the selected alpine plants and in those of lowland plants (Fig.1). Alpine plants, *S.gilashanica* and *Q.aquifolioides* were distinguished by higher levels of the xanthophyll cycle carotenoids relative to in the same genera, lowland plants *S.matsudan*, *Q.aquifolioides*. The difference of the amounts of xanthophyll cycle pigments between alpine and lowland plants indicates that xanthophyll cycle take important effect on resistance to higher irradiances in some alpine plants (Dammig-Adams and Adams 1992). But in alpine plant *R.coriaceum* xanthophyll cycle carotenoid contents were remarkably low, even in comparison with lowland plant *R.macronlatum* (Fig.1). Because the bud scale in the leather leaves of alpine plant *R.coriaceum* reflect light, the light intensity into the leaves decreases.

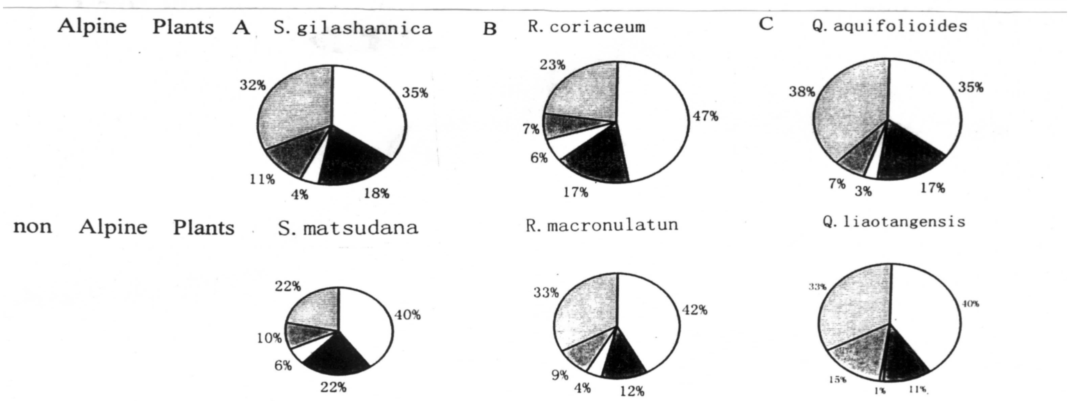

Fig.1. .Carotenoid constituents of chloroplasts of alpine and non alpine plant included: (Group A)S.gilashanica –alpine, S.matsudana—non alpine; (Group B) R.coriaceum -alpine, R.macronulatun- non alpine; (Group C) Q.aquifolioides-alpine Q.liaotangensis- non alpine

V+A+Z=violaxanthin+ antheraxanthin+ zeaxanthin α C= α -carotene

β C= β -carotene L= lutein N= neoxanthin

These fractions were determined on a chlorophyll basis, with the size of each pie respresenting the relative amount of carotenoids present in each type of chloroplasts of alpine and non alpine plants.

Kinetics of Chl *a* fluorescence induction The ratio of variable fluorescence to maximum fluorescence (Fv/Fm) shows the efficiency of the primary conversion of light energy in PSII. In Fig.2 ratio of variable fluorescence to maximum fluorescence (Fv/Fm) from alpine plants (*S.gilashanica*, *S.pilosomicrophylla*, *R.coriaccum*, *R.faucium*, *R.nivale* and *Q.aquifolioides*) were much lower than from lowland plants (*S.babylenica*, *S.massudana*, *R.macronulatum*, *Q.liaotangensis*). The above results may indicate that the efficiency of light energy conversion in PSII were not much higher from these alpine plants than those lowland plants (Guo et al 1995). But the alpine plants are always well adapted to stress environment conditions such as low temperature, strong radiation and low atmospheric pressure. Perhaps the efficiency of light energy conversion in PSII may were stronger from alpine plants than lowland plants in stress conditions.

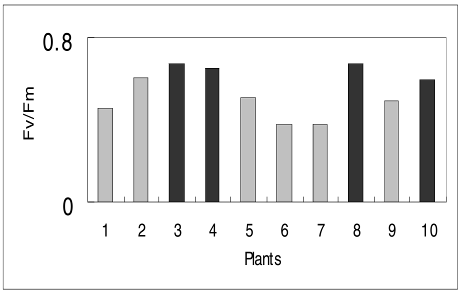

Fig 2 Comparison of Fv/Fm ratio in alpine (grey bar) and non alpine plant (black bar)
1-*S.gilashanica* 2-*S.pilosomicrophylla* 3-*S.babylenica* 4-*S.matsudana* 5-*R.coriaceum* 6-*R.faucium* 7-*R.nivale* 8-*R.macronulatum* 9-*Q.aquifolioides* 10-*Q.liaotangensis*

77K Fluorescence emission and excitation spectra

In the 77K fluorescence emission spectra, at excitation wavelength of 436 nm and 480 nm, the fluorescence emissions in 685-695 nm from PSII, in 710-735 nm from PSI and the fluorescence emission peak at 691 nm, which come from its PSII internal antenna, appeared. If F735 and F684 (or F692) represent the relative fluorescence intensity of PSI and PSII of these plant chloroplasts, the value of F735/F684 and F735/F692 can be applied to estimate the relative amounts of both PSII and PSI complexes (Table 2). The value of F735/F684 and F735/F692 of chloroplasts in the alpine plants was lower than in the lowland plants and so the relative contents of PSII in thylakoid membranes of alpine plants increased.

Table2 Comparison of F735/F684 and F735/F692 ratio of chloroplast in alpine and non aloine plant (77K fluorescence emission, excitation wavelength 436nm and 480 nm)

Species	436nm		480nm	
	F735/F 684	F735/F 692	F735/F 684	F735/f 692
S.gilashanica	0.424	0.649	0.489	1.050
S.matsudana	1.027	1.227	0.930	1.050
R.cariaceum	0.589	0.660	0.648	0.746
R.nivale	0.858	0.901	0.781	0.782
R.macronulutum	1.058	1.143	1.022	1.094
Q.aquifolioides	0.602	0.633	0.602	0.618
Q.liaotangensis	0.814	0.798	0.760	0.706

The results reported for Anderson J.M and Aro E.M (1994) show that sun and high-light plant chloroplasts have many more PSII complexes, each with smaller light- harvesting antennae, relative to PSI, than shade and low-light plants. This result may mean that for supporting high efficiency of photosynthetic conversion of light energy photosynthetic organ have relative more amounts of PSII and the reduced damages by strong radiation. This has resulted in adaption to environment of these alpine plants in Qinghai-Xizang Plateau.

Acknowledgements

We thank Prof.B.S.Li of the Institute of Botany, Chinese Academy of Sciences, for providing experiment material of alpine plant and useful information on ecology of alpine plant. This work was supported in part by a grant from the China State Key Research and Development Plan (G1998010100 and G 1998040803).

References