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Prenylquinones and carotenoids - potential mediators of tolerance of higher plants to combined light and temperature stress

IZEBZO - 143169/1

BSRP, May 2014, Sofia

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Partner organizations:

Institute of Biology, University of Neuchâtel, Neuchâtel, Switzerland

and

Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Sofia, Bulgaria

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Research teams:

Switzerland

Felix Kessler – PI
Gaétan Glauser
Celine Besagni
Livia Spicher- PhD student

Bulgaria

Maya Velitchkova - PI
Antoaneta Popova
Milena Gerganova - PhD student
Auyguyn Faik - PhD student
Daniela Stanoeva
Dimitar Vasilev

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OBJECTIVES

Agriculture and ecosystems are under increasing climate pressure in the changing environment. In most places on the planet temperatures are increasing concomitantly with increasing dryness and light intensities. Therefore in the future crops more resistant to this type of multi-stress will be required. Plant productivity largely depends on photosynthetic activity.

This project aims :

- to discover how the photosynthetic system performs under combinations of various temperatures and light intensities;

- to investigate protective mechanisms at the photosystem, membrane and lipid levels

- to address in a collaborative effort both the physical parameters of photosystems as well as the lipid composition of the surrounding thylakoid membranes.

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METHODOLOGY

CH Group

- ***Non-targeted lipidomics***
- ***Lipid profiling to analyze carotenoids, prenylquinones and membrane lipids under different types of stress***
- ***Electron microscopy***

BG Group

- ***Pulse Amplitude Modulated fluorescence***
- ***Oxygen evolution by leaves and thylakoid membranes***
- ***77K fluorescence***
- ***Flash oxygen yields***
- ***Electrophoresis and Western blot***
- ***UV-VIS spectroscopy***

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Research plan

Work package 1

Prenylquinone, carotenoid and lipid remodeling under temperature and high light stress

Responsible: Prof. F. Kessler

Work package 2

Temperature dependent effects on chloroplast ultrastructure and changes in number and size of plastoglobules

Responsible: Prof. F. Kessler

Work package 3

Changes in the main pigment-protein complex stoichiometry during growth at different combinations of light-temperature

Responsible: Prof. M. Velitchkova

Work package 4

Test the possibility of improving the tolerance of photosynthesis to photoinhibition by combination of the growth temperature and growth light regimes to which the organism is exposed.

Responsible: Assoc. Prof. Antoaneta Popova

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Collaboration aspects

Exchange of expertise and knowledge:

Experiment's design

Methods that complement each other

Exchange of samples for measurements

Discussing and solving methodological problems

Share and discuss data and results

Exchange visits:

Progress meetings of research teams or WP-RSs in Swiss and Bulgaria

Work visits of PhD students for learning of partner's methods and techniques

Participation in scientific events - conferences, congress and workshops

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Milestones of joint project

- ***✓Recruitment of young scientists – two PhD students in BG and one in CH.***
- ***✓Acquisition and upgrade of research equipment (BG only)***
- ***✓High quality collaborative research over 3 years in Arabidopsis and tomato***
- ***✓Implementation of an efficient scientific network between BG and Swiss teams***
- ***✓Publication of data in general interest and plant science oriented journals***

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Effect of low growth temperature

0th day

6th day

5 days of recovery

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In vivo studies
WP 4

Investigations of whole leaves for determination of:

- physiological characteristics – PS1 (P700) and PS2 (O_2 evolution, fluorescence)
- pigments content - chlorophylls and total carotenoids
- membrane integrity - MDA
- synthesis of protective compounds

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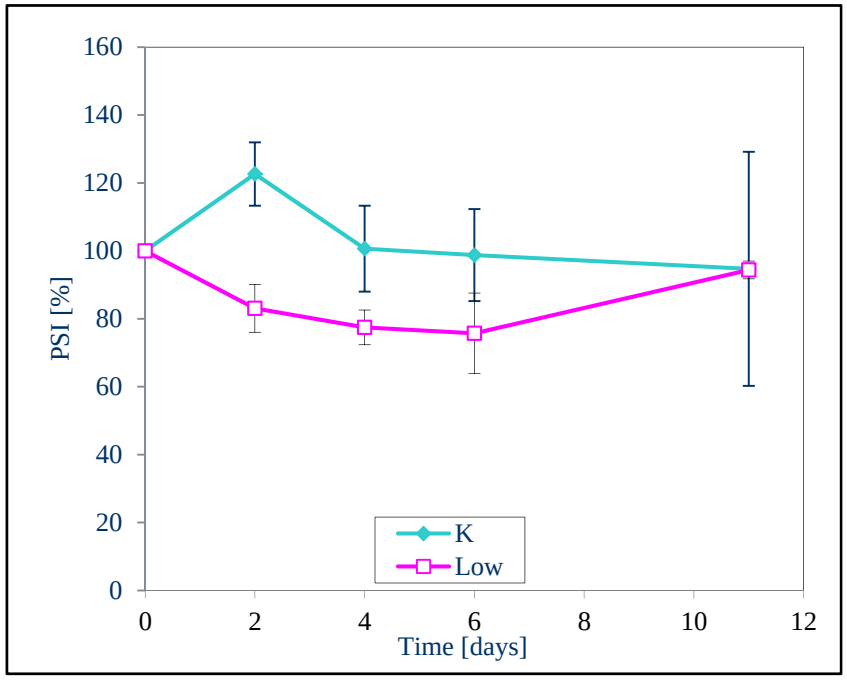
Redox state of PSI, control tomato plants (K) and grown at low temperature (Low).



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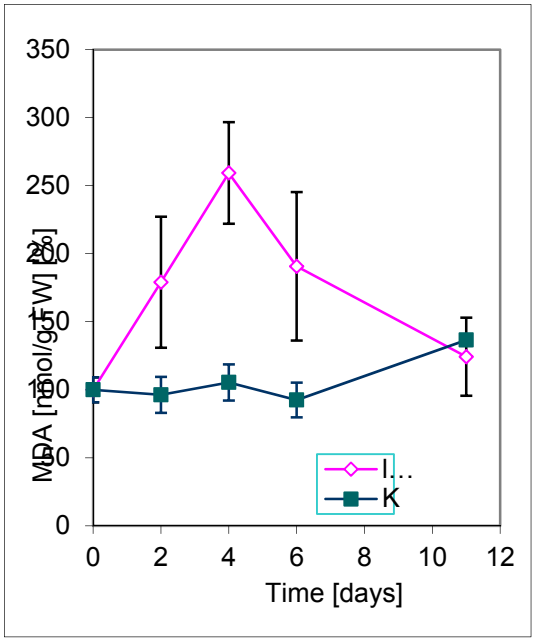
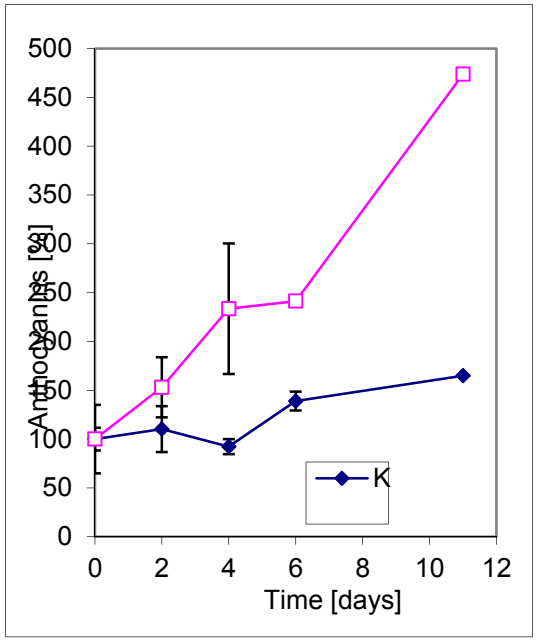
Lipid peroxidation and anthocyanins content in control and LT grown plants





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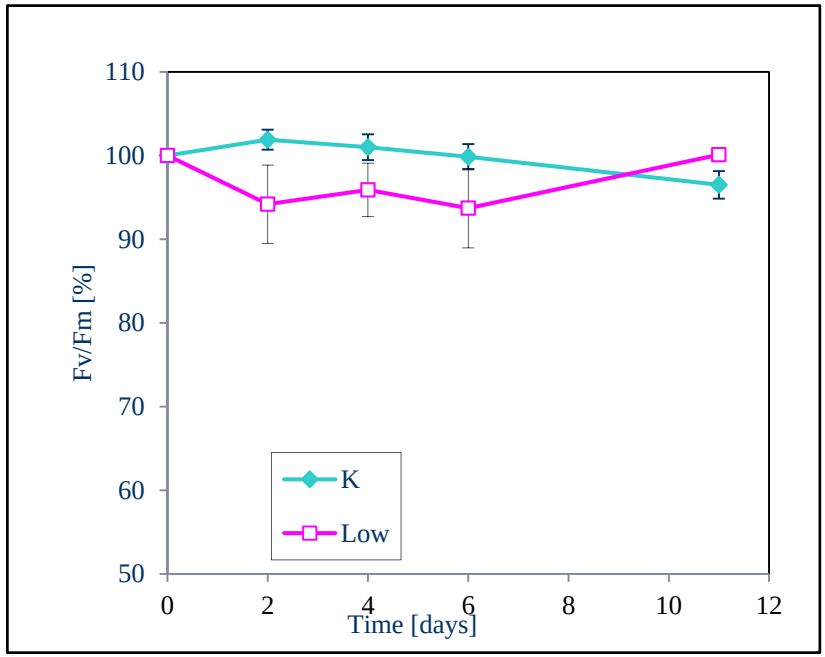
Maximum quantum yield of PSII of tomato plants



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In vitro studies
WP 3

Investigations of isolated chloroplast and thylakoid membranes for determination of:

- photochemical activity of PS1 and PS2
- flash oxygen yields
- excitation energy distribution and interaction
- protein degradation of core complexes and antennas

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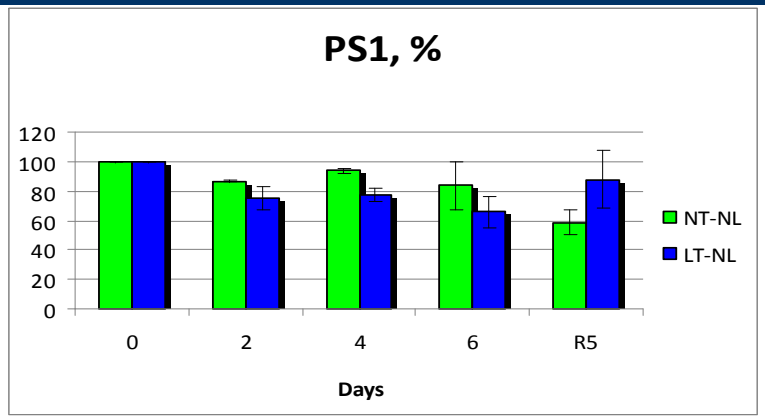
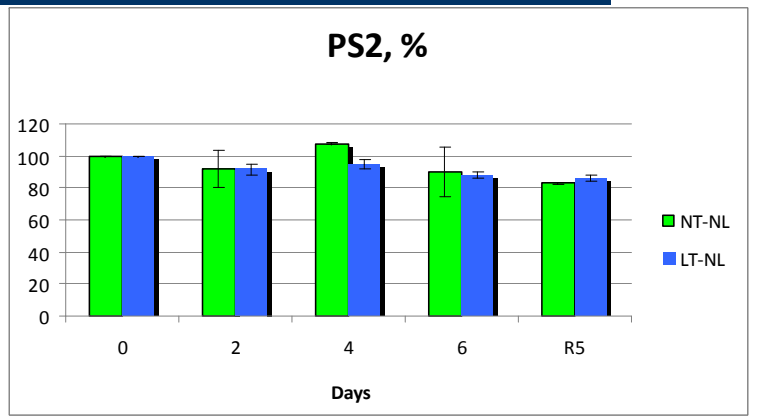
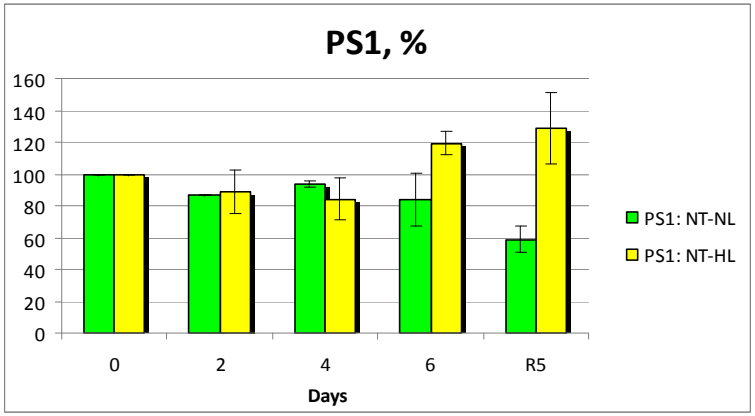
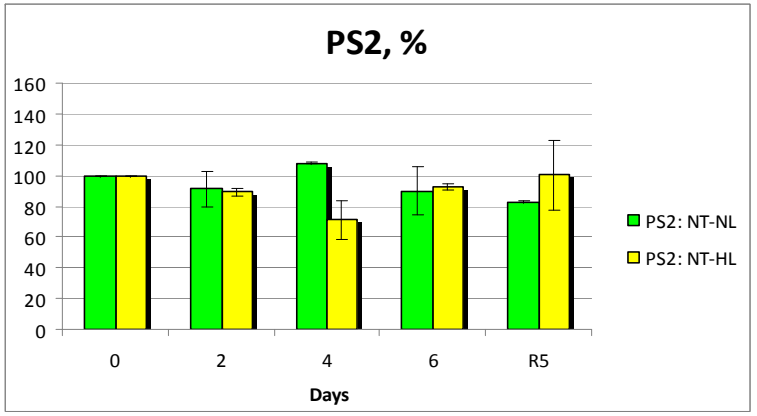
Photochemical activity of PS1 and PS2



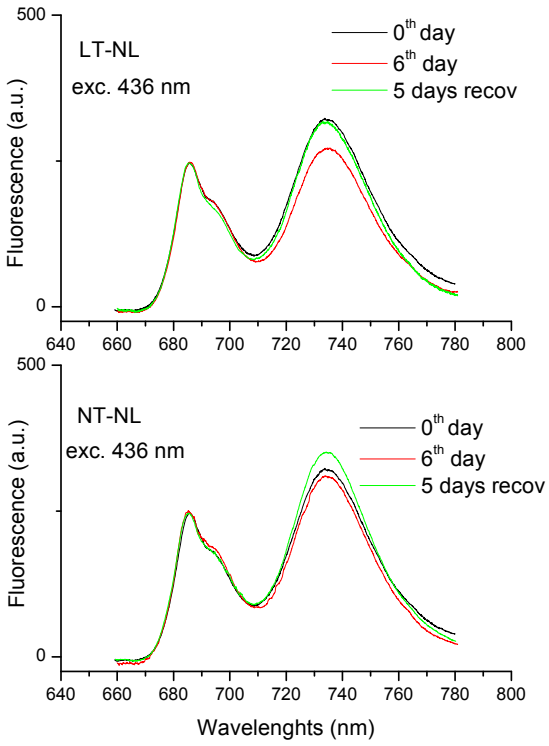




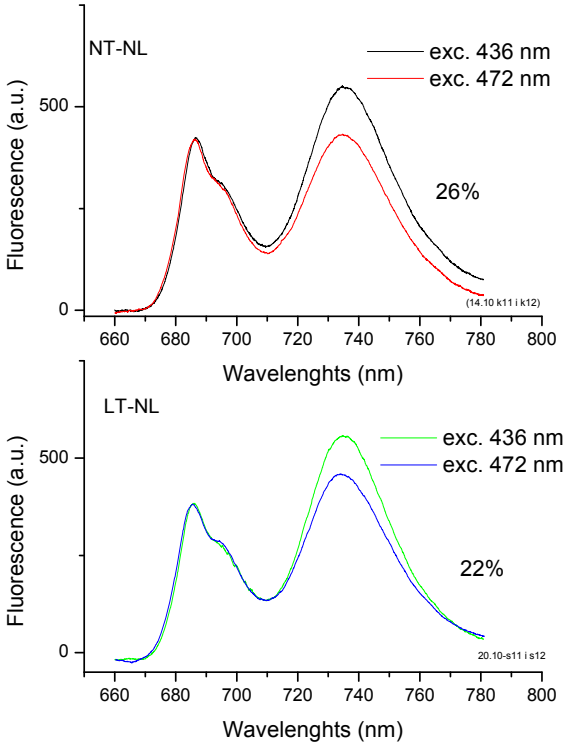


77K fluorescence - excitation energy distribution

Effect of LT on emission spectrum



Effect of exc. 436 nm and 472 nm



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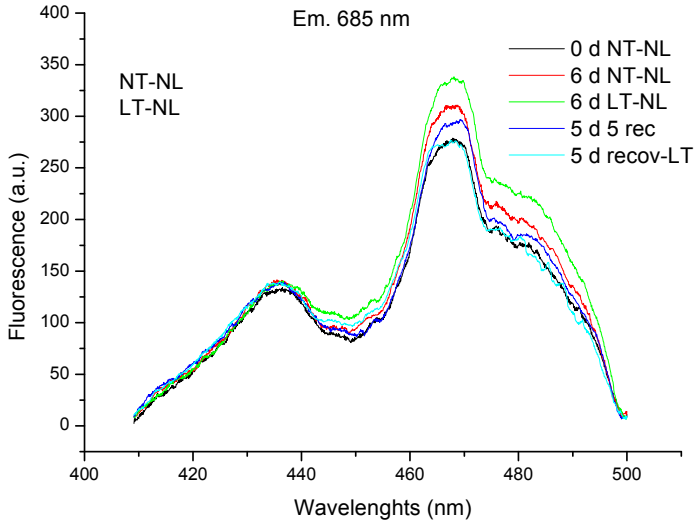
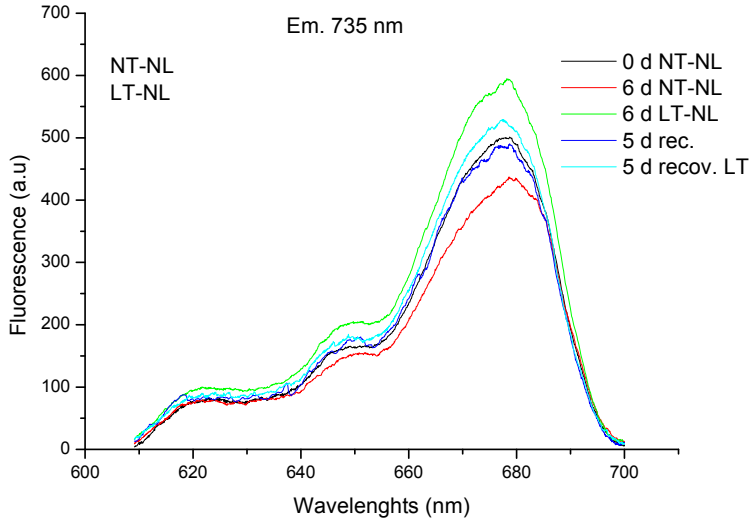
Analysis of fluorescence excitation spectra of PS1 and PS2





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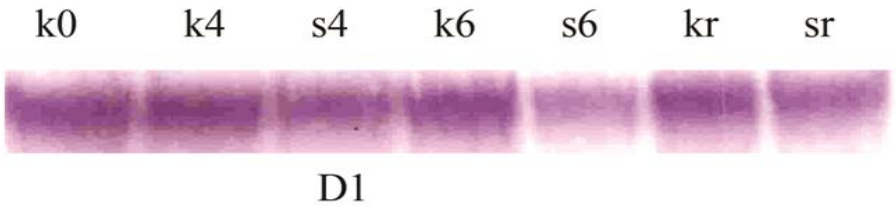
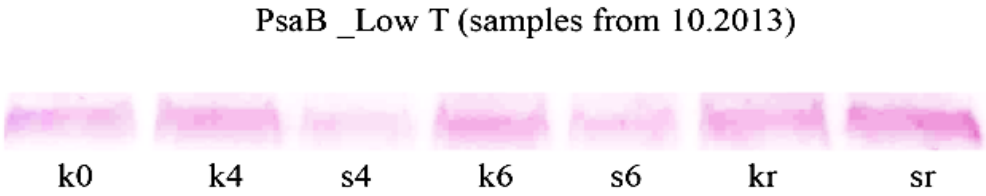
Protein degradation

Photosystem 2



Photosystem 1



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Preliminary conclusions

Tomato plants respond to **high light** illumination treatment by:

- An increase of α and γ tocopherols and anthocyanins;
- Higher degree of lipid peroxidation – damages of membrane integrity;
- A decrease of antenna size of both photosystems and/or detachment of LHC2 from PS1;
- An increase of NPQ as protective mechanism against high light intensity.

Low temperature affects tomato plants as follow:

- Strong increase of anthocyanins content;
- An increase of MDA content up to 4th day of treatment;
- Smaller antenna of PS1 and/or less connection between LHC2 and PS1 - higher extent of thylakoid stacking and lateral dissociation of both photosystems;
- Photochemical activity of PSI and PSII, PSI activity being more affected.

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Research output

At the end of first year of project Bulgarian PhD students took part in International conference **"Bioscience - development and new opportunities" - KLIMENT'S DAYS (Sofia, November 20-22, 2013)**, presenting their preliminary results in three posters:

1. M. Gerganova, D. Vasilev, A. Faik, M. Velitchkova. Effect of low growth temperature on oxygen evolution reactions in tomato and Arabidopsis thaliana plants
2. A. Faik, M. Gerganova, M. Velitchkova, *Changes in energy distribution and photochemical activity of Photosystem I and Photosystem II of tomato plants grown under different light intensities*.
3. K. Dobrev, D. Stanoeva, A.V.Popova. *Effect of low growth temperature on photosynthetic parameters of tomato plants in vivo*.

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Cooperative and organizational aspects

Strengths:
Easy and freely communications between all members of both research teams

Competent and timely responses and answers from the SD of MES and from SNSF

Timely transfers of funds from MES and Swiss partner

Weaknesses:
The inability of BG institutes to open separate bank accounts in Swiss francs, which would greatly facilitate the management and accounting of project

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