Proposal of PhD project to be realized within EU project „Program doskonalenia dydaktyki SGGW w dziedzinie pozyskiwania surowców roślinnych dla energetyki w kontekście celów Strategii Europa 2020”

Supervisor candidate:

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PhD project title:

Long-distance signaling in regulation of the cross-talk between abiotic and biotic stresses – identification of target genes for engineering of stress tolerant energy crops

Environmental stresses such as high light and insect infestation are a major constraint in crop productivity worldwide. There is therefore an urgent need to produce improved crop varieties that are able to maintain growth and crop production over a wide range of climatic variables and so achieve higher and more predictable yields. Thus, enhancing plant performance under various biotic and abiotic stresses is one of the most important issues in agriculture and forestry to achieve high-biomass-yielding crops for food and fuel.
The main part of the project focusses on the analysis of redox/hormone signaling in crosstalk network between abiotic and biotic stresses. The planned research is focused on the experimentally tractable problem of producing crop plants with higher resistance to pests based on an improved knowledge of how exposure to high light influences the plant response to pest infestation. These studies will shed new light a on the nexus of control of stress-related gene expression. The proposed programme of experiments is directly aligned with the priorities of cutting edge research in the area of plant stress biology worldwide.

In the natural environment light is a factor which is constantly changing both during the day and seasonally. “Sun spots” of high intensity are perceived by plants daily. Light controls growth and development throughout the plant life cycle, however light exceeding the capacity of the photosystems can be destructive. To cope with the HL stress plants evolved several photo-protective mechanisms and induce systemic acquired acclimation (SAA), in which exposed, stressed tissues of individual plants communicate to the distal parts of the plant (Karpinski *et al*., 1999). It has been shown that systemic part of the plant is acclimated to high light challenge and resistant to several pathogens. The retrograde signaling from the chloroplast to nucleus is an essential part of plant responses to multiple stresses and helps the plant to optimize photosynthesis and regulate the growth to survive unfavorable conditions. Inter-organellar communication is necessary for the integration of the cell signaling under the complex exposure of plant to multiple stresses induced both by abiotic and biotic factors to coordinate the expression of nuclear genes. It is believed that retrograde redox-signaling initiated by chloroplast is induced by rapid increases in light intensity, temperature, or changes in relative humidity and water and CO_2 availability. These signals control the stomatal aperture to adjust optimal gas exchange, photosynthesis and transpiration and regulate SAA and systemic acquired resistance (SAR) in response to pathogens. The role of plastid–nucleus signal transduction in the regulation of acclimation and immune defense responses against pathogen has been extensively studied and has been reviewed recently (Karpinski *et al.,* 2012), nevertheless the role of such signals in plant defenses against insect herbivores has not been yet analyzed. Thus, the studies will include the role of systemic signals induced by high light "spots" on pests' performance including aphids and mites. The role of different photo-protective mechanisms and high light-induced reactive oxygen species (ROS) on retrograde signaling from plastid to nucleus during combined stresses will be studied. The transcriptomics, metabolomics together with measurement of antioxidant capacity and photosynthetic performance will be performed using appropriate mutants and crosses. Additionally, the role of high light-induced volatile compounds on plant acclimation to both stresses including within- plant and plant- plant communication will be further analyzed. The main part of the project will be performed on the model plant *Arabidopsis thaliana* however the studies will be further extended on the other systems like potato and poplar. The expected results will help in designing alternative pest control strategies. Such strategies may include natural "green pesticides" isolated or released by plants, non-GMO solutions by pointing best targets for mutant screenings (eg. via TILLING technique - McCallum *et al.* 2000) or for site directed approaches with TALEN nucleases (Christian *et al.,* 2010).

Selected publications:

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- Mühlenbock P, Szechyńska-Hebda M, Płaszczyca M, Baudo M, Mateo A,. Mullineaux P M, Parker JE, **Karpinska B** and Karpiński S (2008) Chloroplast Signaling and *LESION SIMULATING DISEASE1* Regulate Crosstalk between Light Acclimation and Immunity in *Arabidopsis*. Plant Cell **20,** 2339–2356.
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- Larsson KA, Saheed SA, Gradin T, Delp G, **Karpinska B**, Botha CE, Jonsson LM (2011) Differential regulation of 3-aminomethylindole/N-methyl-3-aminomethylindole N-methyltransferase and gramine in barley by both biotic and abiotic stress conditions. Plant Physiol Biochem. **49**, 96-102.
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Professional Experience:

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- **2001 - 2006** **Scientist (assistant professor) at Stockholm University, Docent in biology, specialization in plant molecular biology, Department of Botany, Stockholm, University, SE-106 91 Stockholm, Sweden**

- **1998 - 2001** **Post Doc Fellow, Department of Forest Genetics and Plant Genetics and Plant Physiology, SE-901 83 Umeå, Sweden**

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