The 21st Prof. Evenari Symposia

How do plants cope with stress?

Monday, June 7th, 2010 at the George Evens Family Auditorium, Sede Boqer Campus

Zygophyllum dumosum
### PROGRAM

#### Greetings
10:00  **Prof. S. Boussiba**, Head, The French Associates Institute for Agriculture and Biotechnology of Drylands
10:05  **Prof. A. Vonshak**, Director, Blaustein Institutes for Desert Research
10:10  **Prof. Y. Gutterman**, Blaustein Institutes for Desert Research

#### Lectures

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<td><strong>Asaph Aharoni</strong></td>
<td>The Weizmann Institute of Science, Rehovot, Israel</td>
<td><em>How do plants coat their surface? lessons from Arabidopsis and tomato</em></td>
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<td>11:00</td>
<td><strong>Ari Schaffer</strong></td>
<td>ARO, The Volcani Center, Bet Dagan, Israel</td>
<td><em>Role of the cuticle in water preservation in the ripe tomato fruit</em></td>
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<td><strong>Simcha Lev-Yadun</strong></td>
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<td>LUNCH and tour in experimental facilities</td>
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<td>The French Associates Institute for Agriculture and Biotechnology of Drylands, Ben Gurion University, Israel</td>
<td><em>Imbalance in plant sulfite homeostasis results in premature senescence and plant death</em></td>
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<td>The French Associates Institute for Agriculture and Biotechnology of Drylands, Ben Gurion University, Israel</td>
<td><em>Epigenetic mechanisms associated with drought tolerance in the desert plant Zygophyllum dumosum Boiss</em></td>
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<td><strong>Simon Barak</strong></td>
<td>The French Associates Institute for Agriculture and Biotechnology of Drylands, Ben Gurion University, Israel</td>
<td><em>Using Arabidopsis and Arabidopsis relative model systems to understand how plants cope with abiotic stresses</em></td>
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<td><strong>Shimon Rachmilevitch</strong></td>
<td>The French Associates Institute for Agriculture and Biotechnology of Drylands, Ben Gurion University, Israel</td>
<td><em>Roots and salinity: new findings</em></td>
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HOW DO PLANTS COAT THEIR SURFACE? LESSONS FROM ARABIDOPSIS AND TOMATO

Asaph Aharoni

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One of the most fundamental changes in the adaptation of plants to terrestrial environment was the formation of their surface, the cuticle. The cuticular layer plays multiple roles in plants including the regulation of epidermal permeability and non-stomatal water loss and the protection against insects, pathogens, UV light, and frost. It also functions in the prevention of post-genital organ fusion, pollen-pistil interactions and cell-to-cell communication. Generation of cuticular components in epidermal cells involves two major independent biosynthetic pathways, namely, the synthesis of cutin monomers and aliphatic wax components. Most plant species frequently contain additional classes of metabolites in the cuticle such as triterpenoids and aromatic metabolites (e.g. flavonoids). Our lab is interested in the regulation of the different metabolic pathways constructing the cuticle. We also investigate how the different chemicals are secreted to the extracellular matrix for the assembly of the cuticular layer. Two major model systems, namely Arabidopsis and tomato, are used in parallel for the investigation of plant vegetative and reproductive organs surface. In the past years we have been characterizing a small clade of ABC-type transporter genes that are involved in the transport of cuticle components from the epidermal layer, through the plasma membrane to the surface. The results provide evidence that this clade members function in the transport of wax and cutin constituents and possibly suberin (chemically similar to the cutin polymer). At the level of transcriptional regulation, we are conducting in-depth characterization of the SHINE (SHN)/WAX INDUCER (WIN) clade of transcription factors that control the cutin biosynthesis pathway. Arabidopsis plants silenced for all three SHINE genes were examined for alterations to gene expression using microarrays and two dozen putative target genes were detected. In parallel to the study in Arabidopsis, we are also investigating the cuticle in both vegetative as well as reproductive organs in tomato.
Extensive metabolic and gene expression profiling of the fruit peel tissue revealed a set of approximately 600 genes associated with tomato fruit peel. Among this set we have identified a putative orthologue of the SHN genes that is highly expressed at the early, immature green stage of tomato fruit development. Overexpression of this gene in tomato resulted in plants displaying glossy/shiny leaves that accumulate epicuticular wax on both leaves and fruit. Tomato also accumulates flavonoids in the thick cuticular layer surrounding the fruit epidermal layer. The colorless peel y mutant of tomato lacks the flavonoid naringenin chalcone, a yellow pigment that accumulates up to 1% of the cuticular layer. We have recently identified a regulatory gene that is responsible for the y phenotype and results from this study will be presented. All together, this work provides insight to the molecular and chemical basis for cuticle assembly in both vegetative as well reproductive plant organs.

Polar localization of the DEPERADO (DSO) ABC-type transporter protein in epidermal cells of the Arabidopsis stem. The DSO protein is required for the transport of cutin and wax components through the plasma membrane of epidermal cells to the extra cellular matrix. Confocal microscopy of stem cross-sections of plants harboring the promoter $DSO::GFP-DSO$ construct showed that DSO is localized in a polar manner in epidermis cells. ep- indicates epidermal cells and cor- cortex cells.
ROLE OF THE CUTICLE IN WATER PRESERVATION IN THE RIPE TOMATO FRUIT

Ari Schaffer

Department of Vegetable Research, Volcani Center, Bet Dagan

One of the most intriguing phenomena unique to fleshy fruit is their ability to maintain high water content (up to 95%) at maturity. This capability is accomplished by a fruit cuticle that is highly impermeable to water diffusion, as exemplified by the tomato, and is one of the factors that contributed to the widespread cultivation of the juicy fruit. We identified a gene (Cwp, Cuticular water permeability), which is expressed only in fruit of primitive relatives of tomato and which became silenced during the evolution of the Lycopersicon genus. The expression of the gene in the cultivated tomato species Lycopersicon esculentum, either by heterologous transgenic expression or by introgression of the allele from wild species into the cultivated tomato background, causes a modified fruit cuticle leading to dehydrated fruit, analogous to raisins. The gene product has an unidentified function but clearly contributes to cuticular development. Irrespective, the preadaptive silencing of the expression of this gene during the evolution of the tomato has allowed for the development of one of the most water retentive fruits known, which was to human advantage.
APOSEMATIC (WARNING) COLORATION OF SPINY PLANTS

Simcha Lev-Yadun

Department of Science Education - Biology, University of Haifa - Oranim, Tivon 36006, Israel. E-mail levyadun@research.haifa.ac.il

Aposematic coloration, a well-known phenomenon in animals, has been given little attention in plants. Spiny/thorny plants are common in arid regions and the majority of them have colorful (yellow, orange, purple, black, white) spines and thorns. The spiniest taxa (Asteraceae in the Near Eastern flora, Cacti and the genus Agave in America and the genera Aloe and Euphorbia in Africa) are typical examples. The phenomena have already been found in several thousand species originating in several continents of both the Old and New World. I propose that this is a type of vegetal aposematic coloration signaling herbivores about the defensive qualities of the plants. Mullerian and Batesian mimicry rings of this phenomenon are common.
FUNGAL LIFE IN THE DEAD SEA: EVOLUTIONARY AND AGRICULTURAL TREASURE

Eviatar Nevo
Institute of Evolution, University of Haifa

Biodiversity in extreme environments provides unique natural evolutionary tests for life processes at the edge, climaxing the organism-environment relationship into the threshold of life. The organisms surviving or even evading extreme environments display extreme biology and evolutionary adaptive complexes at both the genotype and phenotype levels which provide insights into the general nature, origin, and evolution of life. The Dead Sea, one of the most stressful hypersaline environments across the planet, represents a unique and very extreme environment, hence it provides one of nature’s supreme tests of extreme life in general.

I will review our novel and unexpected discovery of 77 species of filamentous fungi in the Dead Sea from evolutionary and agricultural perspectives. Most species are sporadic but a minority core are widespread and some reach the bottom of 300 meter. They usually persist as spores but develop variegated mycelia when the sea water are heavily diluted by rain floods. The evolution of the Dead Sea led to extreme salinization (~340 g/liter salinity) and its filamentous fungi evolved very promising genetic resources in resisting salinity and other stresses (Jin et al., 2005). The Dead Sea is potentially an excellent model for studying evolution under extreme environments and advancing saline agriculture.

References


IMBALANCE IN PLANT SULFITE HOMEOSTASIS RESULTS IN PREMATURE SENESCENCE AND PLANT DEATH

Moshe Sagi

The French Associates Institute for Agriculture and Biotechnology of Drylands, The Blaustein Institutes for Desert Research, Ben Gurion University, Sede Boqer Campus, Israel

Sulfur is available to plants as an oxidized anion sulfate, which is taken up and reduced via APS to sulfite and sulfide that is incorporated into cysteine in a pathway of sulfate assimilation. Apart from sulfate, plants are capable of utilizing alternative sources of sulfur such as the atmospheric sulfur dioxide. Sulfur dioxide and sulfite is readily hydrated in water to form the sulfite strong nucleophile ions, HSO₃⁻ and SO₃²⁻. Above a certain threshold, sulfite can deleteriously affect plant tissue and therefore its levels in the cell have to be carefully balanced in a interplay between its application/production and conversion. We hypothesize that an interaction between APS reductase, which generates sulfite, and the rest currently known “sulfite network” enzymes that utilize sulfite, SiR, SQD1, SO, and MST, is important for controlling sulfite level in plants. A role for sulfite oxidase in sulfite homeostasis is demonstrated in plants subjected to: a) high exogenous application and b) growth conditions that enhance endogenous sulfite generation.
EPIGENETIC MECHANISMS ASSOCIATED WITH DROUGHT TOLERANCE IN THE DESERT PLANT 
ZYGOPHYLLUM DUMOSUM BOISS

Gideon Grafi

The French Associates Institute for Agriculture and Biotechnology of Drylands, The Blaustein Institutes for Desert Research, Ben Gurion University, Sede Boqer Campus, Israel

Zygophyllum dumosum Boiss. is a perennial Saharo-Arabian phytogeographical element and a dominant shrub on the rocky limestone southeast-facing slopes of the Negev desert. The plant is highly active during the winter, and semideciduous during the dry summer, that is, it sheds its leaflets, while leaving the thick, fleshy petiole green and rather active during the dry season. Being resistant to extreme perennial drought, Z. dumosum appears to provide an intriguing plant for studying epigenetic mechanisms underlying drought resistance in natural habitats. The transition from the wet to the dry season was accompanied by a significant decrease in nuclear size associated with posttranslational modifications of Histone H3 N-terminal tail. Dimethylation of H3 at lysine 4 (H3K4) – a modification associated with active gene expression – was found to be high during the wet season but gradually decreased on the transition to the dry season. Unexpectedly, H3K9 dimethylation and trimethylation could not be detected in Z. dumosum but in other desert plants, such as Artemisia sieberi, Anabasis articulata and Haloxylon scoparium; H3K9 monomethylation appears to be prominent in Z. dumosum during the wet but not the dry season. Our results demonstrate unique and dynamic pattern of histone H3 methylation and genome organization displayed by Zygophyllum dumosum, which could have an adaptive value in variable, hostile environments of the Negev desert.

Reference:
USING *ARABIDOPSIS* AND *ARABIDOPSIS* RELATIVE MODEL SYSTEMS TO UNDERSTAND HOW PLANTS COPE WITH ABIOTIC STRESSES

Simon Barak

The French Associates Institute for Agriculture and Biotechnology of Drylands, The Blaustein Institutes for Desert Research, Ben Gurion University, Sede Boqer Campus, Israel

Abiotic stresses such as drought, high salinity and temperature extremes lead to many adverse effects on plant physiology and are a primary cause of crop loss worldwide. Plant responses to stress require the coordinated regulation of many signaling networks, which converge to a set of transcription factors that together activate the expression of numerous downstream stress response genes. As part of our efforts to understand how plant stress responses are regulated, we have constructed a "stress gene" database of hundreds of microarray datasets examining global gene expression in *Arabidopsis thaliana* in response to various abiotic stresses. Using this database, we are carrying out a bioinformatics-based screen for regulatory genes that control *Arabidopsis* responses to multiple abiotic stresses. This screen has identified two mutants that are defective in genes encoding DEAD-box RNA helicases, which we have designated *STRS1* and *STRS2*, and whose expression is down-regulated in response to multiple stresses. We will present our results showing that the *STRS* genes are negative regulators of multiple abiotic stress responses and that they may function in the nucleolus and in heterochromatin regions of the chromosomes.

Another approach that we have taken to understanding plant responses to abiotic stresses has been to study close relatives of *Arabidopsis* that are naturally tolerant to multiple abiotic stresses. We show that one such extremophile plant, *Thellungiella halophila*, can tolerate high levels of salinity and also exhibits tolerance to low nitrate stress. We show that differences in stress tolerance between *Arabidopsis* and its extremophile *Arabidopsis* relatives involves differential regulation of the same set of stress tolerance genes. Finally, some recent research will be presented examining abiotic stress tolerance mechanisms in *Arabidopsis* relatives from the Negev Desert.
ROOTS AND SALINITY: NEW FINDINGS

Shimon Rachmilevitch

The French Associates Institute for Agriculture and Biotechnology of Drylands, The Blaustein Institutes for Desert Research, Ben Gurion University, Sede Boqer Campus, Israel

Salinity is a major environmental stress for plants in general and especially for roots that have major effects on the response of the whole plant. Roots are responsible for the acquisition of nutrients and water from the soil and play a major role in whole plant growth, productivity and tolerance; however root research has been neglected compared to above-ground parts research. Two independent studies with new findings on root behaviour in response to salinity will be presented, including: 1) water uptake and 2) tropism.

The role of root orders on water uptake rates was studied. Water uptake was higher in first order roots and was significantly related to root orders and not to the distance, diameter or their position within the root system. We found water excess from higher root orders which is a new phenomenon and is suggested to be caused by leaking membranes or by purpose to secure survival of water-transporting coarse roots. Root order related water uptake changed under different nutrient and stress regimes. In addition

Roots control their growth orientation by displaying differential growth (i.e. a tropism) in response to environmental cues such as gravity and water content. Gravitropic responses are widely studied; however other tropisms in roots have not been studied extensively. Our observations on root architecture of Bassia indica in field and greenhouse studies, offer that roots may exhibit tropism cued by salinity ("halotropism") in which roots grow towards salt. In addition to the novel finding of halotropism we have studied the potential of Bassia indica as an efficient bio-remediation plant.
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Photo: Prof. Yitzhak Gutterman