Course B390B: Special Topics, for 3 credits

Salinity tolerance: a case study in plant physiology and adaptation

Course leader: Professor Mark Tester

The **aim** of this course is two-fold:

i) to present a comprehensive overview of plant responses to salinity and the many adaptations plants have evolved to salinity

ii) to provide an overview of plant physiology and anatomy, this being done in the process of understanding mechanisms of salinity tolerance

The course is a graduate level course, and requires a basic understanding of biology and chemistry.

Contact: Timetabled to be 3 hours/week, 10.30-12.00 on Tuesday & Thursday from 19 August to 4 Dec.
NOTE: Due to the Center for Desert Agriculture's lab meetings on Thursday, the **Thursday** lectures will slide by 30mins, to be from **11.00-12.30**. The **Tuesday** lectures will stay at **10.30-12.00**.

Overall, we will have 12 x 1.5 hour lectures; 8 x 1.5 hour student-driven tutorial sessions; and a range of other talks, tutorial sessions and exercises as outlined in the timetable below.

Tutorials are an informal question-and-answer session, driven by students' questions.

Location: Building 9, Room 2120 – at least for the first lecture. Then Building 2, Room 5220

Assessment: There will not be an exam during this course. The course will be assessed using the following four aspects:

1. Groups of 2-3 students will make a poster in which will be presented a proposal for a research project	25%
2. Individuals give a 20 min talk centered on 1 paper from the past year	25%
3. A written review (1,000 words) on a specific area of research	30%
4. Participation and engagement in the course	20%

The written essay can be related to the oral presentation, but must include consideration of at least 5 further primary research papers. The word count must be strictly adhered to; it refers to the body of text, and does not include title, references or figure legends. The essay is due by 5pm on 9 December. Students will lose 1 mark (out of the total of 30) for every hour after then. MT and SN will audit the topics for all work.

Course timetable

The first lecture will be in Building 9, Room 2120. Subsequent lectures will then all be in Building 2, Room 5220

Tues	19 Aug	Lecture 1. Background on salinity
Thurs	21 Aug	Lecture 2. Toxicity and tolerance
	25-30 Aug	*MT in Iran* Two guest talks
Tues	26 Aug	Guest talk from Dr Sandra Schmoeckel
Thurs	28 Aug	Guest talk from Dr David Jarvis
Tues	2 Sept	Tutorial 1 – with SS, DJ, MT and SN
Thurs	4 Sept	Lecture 3. Methods to study tolerance I (SN)
Tues	9 Sept	Lecture 4. Methods to study tolerance II (SN)
Thurs	11 Sept	Tutorial 2
Tues	16 Sept	Lecture 5. Methods to study tolerance III (SN)
Thurs	18 Sept	Visiting Professor: Klaus Pillen
Tues	23 Sept	Tutorial 3
Thurs	25 Sept	Lecture 6. Osmotic tolerance I
Tues	30 Sept	Lecture 7. Osmotic tolerance II
Thurs	2 Oct	Tutorial 4 (Dr Negrão)
	2-25 Oct	*MT in Europe* Work on poster presentations (with Dr Negrão)
		Tutorial 5 (with Dr Negrão) during this time, too
Tues	28 Oct	Group poster presentations
Thurs	30 Oct	Lecture 8. Ion exclusion I
Tues	4 Nov	Lecture 9. Ion exclusion II
Thurs	6 Nov	Tutorial 6
Tues	11 Nov	11.00-12.00 Prof Nils Stein, Distinguished Lecture
Thurs	13 Nov	Lecture 10. Ion exclusion III
Tues	18 Nov	Lecture 11. Tissue tolerance
Thurs	20 Nov	Tutorial 7
	23-27 Nov	*MT in Japan*
Tues	25 Nov	Journal club presentations (with Dr Negrão)
Thurs	27 Nov	Journal club presentations (with Dr Negrão)
Tues	2 Dec	Lecture 12. Conclusions and summary
Thurs	4 Dec	Tutorial 8
	7-9 Dec	*Exam period – use time for completing essay.* ***DUE 5pm on 9 Dec***
Thurs	11 Dec	12.00-2.00 End-of-course lunch

Outline of lectures in more detail

1. Background on salinity

Outline of the course
Saline soils – defining salinity
Scale of the problem
Cost of the problem
KAUST's CDA-WDRC aims
Symptoms of salinity toxicity – incl dicot and monocot leaf anatomy

What are the toxic ions – toxicity and deficiency

2. Toxicity and tolerance

Why are the toxic ions toxic?
Osmotic toxicity – inhibited growth
Ionic toxicity – accelerated death
Water use efficiency (WUE) and stomatal function
Harvest index (HI) – starch storage and phloem function
Plant variation in tolerance – different scales of variation
Halophytes and glycophytes – salt exclusion and salt accumulation
Surviving versus thriving
Mechanisms of tolerance – overview
Osmotic tolerance, ion exclusion, tissue tolerance, increased WUE, HI

3, 4 & 5. Methods to study tolerance – by Dr Sónia Negrão

Phenotyping salinity tolerance, including The Plant Accelerator
Forward genetics – bi-parental, association, nested association, MAGIC
Forward genetics – Mendelian genetics, quantitative genetics
Reverse genetics
The -omics (genomics, transcriptomics, proteomics, metabolomics)
Characterisation of genes – heterologous expression systems (bacteria, yeast, cell cultures, Xenopus)
Characterisation of genes – transgenics, mutants, natural variation
Delivery of improved crops – marker-assisted selection, genetic modification

6 & 7. Osmotic tolerance

Rapid inhibition of growth, reducing rates of new leaf production
Stomatal closure
Inhibition of cytokinesis
Cell signaling – changes in cytosolic Ca^{2+} activity
Whole plant signaling – ROS waves, Ca^{2+} waves, electrical signals
The Plant Accelerator for quantifying osmotic tolerance
Forward genetic studies of osmotic tolerance
Relationship to yield in the field
Water use efficiency and harvest index

8, 9 & 10. Ion exclusion

Correlation between leaf blade [Na^+] and tolerance
Ion transport – thermodynamics
Ion transport – mechanisms
Na^+ entry, Ca^{2+}-sensitive Na^+ transport, non-selective cation channels
Root sequestration of Na^+
Root-to-shoot transfer of Na^+ - root anatomy, transport thermodynamics
The role of *HKT1* in controlling root-to-shoot Na^+ transport
Forward genetic approaches to studying Na^+ transport
-omics approaches to studying Cl^- transport

11. Tissue tolerance

Intracellular compartmentation of Na^+ - accumulation in the vacuole
Compatible solutes – synthesis and accumulation in the cytoplasm
Inter-cellular compartmentation of Na^+ - accumulation in the epidermis
Intra-shoot compartmentation of Na^+ - sacrificing old leaves
Salt glands
Halophytes and glycophytes

12. Conclusions

As it says!

Example areas for Presentations and Essays

HKT Original studies
Stelar-specific over-expression
Introgression into durum wheat
HKT in rice
Field trials

AVP Original studies – the biochemistry
Original studies – identifying the genes
Transgenic work – tomato, barley, etc
Forward genetic studies in barley
The real *in planta* function of *AVP*
Field trials

CIPK *SOS3/SOS2/SOS1*
The overall CIPK gene family
SOS2 and its mechanism of action
AtCIPK16 – the forward genetics work
Field trials

Role of epigenetics in salinity tolerance
e.g. the papers of:
Suter & Widmer (2013) *PLoS ONE* **8**(4): e60364
Sani et al. (2013) *Genome Biology* **14**: R59
Where are the field trials?!

In addition to the primary and review literature provided during lectures, the following textbook also provides useful background information:
Taiz & Zeiger (2010) *Plant Physiology*, 5th edition
http://www.coursesmart.com/IR/6071481/9780878938667?__hdv=6.8