

Functional Plant Biology

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Volume 44 Issue 9 2017

Special Issue: Flooding and Low Oxygen Responses in Plants

Foreword: Flooding and low oxygen responses in plants

Ole Pedersen, Pierdomenico Perata and Laurentius A. C. J. Voesenek iii–vi

Anatomical and biochemical characterisation
of a barrier to radial O₂ loss in adventitious roots
of two contrasting *Hordeum marinum* accessions
**Lukasz Kotula, Lukas Schreiber,
Timothy D. Colmer and Mikio Nakazono**

845–857

A barrier to radial oxygen loss (ROL) in roots is an important adaptation of many wetland plants growing in waterlogged, anoxic soils; however, knowledge of the nature of the barrier is sparse. The ROL barrier enhances longitudinal oxygen diffusion through aerenchyma to the root tip. Our comparison of two *Hordeum marinum* accessions differing in ROL barrier strength showed that the deposition of suberin into walls of the root exodermis is associated with reduction in loss of oxygen from basal root zones to the external medium.

Environmental factors constraining adventitious
root formation during flooding of *Solanum dulcamara*
**Qian Zhang, Heidrun Huber,
Jannah W. T. Boerakker, Daniek Bosch,
Hans de Kroon and Eric J. W. Visser**

858–866

Flooding generally poses a threat to terrestrial plants, but wetland species display adaptations that prevent damage by the adverse conditions imposed by floods. One of these adaptations – formation of adventitious roots that replace the original non-adapted root system – may be severely constrained if insufficient light or contact of leaves with the atmosphere is present during the flooding event. This results in significantly fewer adventitious roots growing out of the stem, and thus poor performance in these stressful conditions.

Contrasting oxygen dynamics in *Limonium narbonense*
and *Sarcocornia fruticosa* during partial
and complete submergence
**Elisa Pellegrini, Dennis Konnerup, Anders Winkel,
Valentino Casolo and Ole Pedersen**

867–876

Halophytes represent extraordinary strategies of flooding tolerance, most of them poorly understood. Traits associated with internal tissue aeration are often essential to submergence tolerance but the present study shows that other traits may also be relevant in order to sustain growth under recurrent submergence. Understanding traits that confer flooding tolerance is important in times with global climate changes that worldwide are predicted to result in more frequent flooding events.

Leaf gas film retention during submergence
of 14 cultivars of wheat (*Triticum aestivum*)
**Dennis Konnerup, Anders Winkel, Max Herzog
and Ole Pedersen**

877–887

Some terrestrial plants, including wheat (*Triticum aestivum*), possess superhydrophobic leaf surfaces that retain a thin gas film when submerged. We tested gas film retention time of 14 different wheat cultivars and found that wheat could retain the gas films for a minimum of 2 days. We suggest that leaf gas film is a relevant trait to use as a selection criterion to improve the flood tolerance of crops that become temporarily submerged.

Cover illustration: Partially submerged Chamomilla recutita after a flash-flood. In water, molecular diffusion of O₂ is slow and the present issue is devoted to low oxygen responses in plant tissues during flooding. Photo by Ole Pedersen.

<p>Flood tolerance of wheat – the importance of leaf gas films during complete submergence <i>Anders Winkel, Max Herzog, Dennis Konnerup, Anja Heidi Floytrup and Ole Pedersen</i></p>	888–898	<p>Climate changes result in more floods also in regions where the mean precipitation is predicted to decline. Dryland crops such as wheat and barley are particularly vulnerable to submergence stress. Here, we show that superhydrophobic leaf surfaces enhance survival of completely submerged wheat by formation of thin leaf gas films that helps wheat to ‘breathe’ under water.</p>
<p>No escape? Costs and benefits of leaf de-submergence in the pasture grass <i>Chloris gayana</i> under different flooding regimes <i>Gustavo G. Striker, Celia Casas, Xiaolin Kuang and Agustín A. Grimoldi</i></p>	899–906	<p>Elongation-induced leaf emergence (escape strategy) is hypothesised to be more beneficial under single long-term submergence than under repeated short-term submergence. We tested this idea in <i>Chloris gayana</i> Kunth. grass. We found that under a single 2-week submergence event, plants accumulated a 2.9-fold higher dry mass than when experiencing the same submergence duration in separate events along 1 week, validating our hypothesis.</p>
<p>Improvement of submergence tolerance in rice through efficient application of potassium under submergence-prone rainfed ecology of Indo-Gangetic Plain <i>Sharad Kumar Dwivedi, Santosh Kumar, Narayan Bhakta, Shishir Kant Singh, Karnena Koteswara Rao, Janki Sharan Mishra and Anil Kumar Singh</i></p>	907–916	<p>Potassium (K) is one of the limiting factors that influenced rice growth and yield in submergence prone soils. Here we show that application of K at a higher dose (40 kg K₂O ha⁻¹ (basal) + one foliar spray at 0.5% K at panicle initiation stage) was beneficial in improving rice survival and grain yield. This finding will aid in boosting rice productivity in submergence prone rainfed ecology of Eastern Indo-Gangetic Plain.</p>
<p>A calcineurin B-like protein participates in low oxygen signalling in rice <i>Viet The Ho, Anh Nguyet Tran, Francesco Cardarelli, Pierdomenico Perata and Chiara Pucciariello</i></p>	917–928	<p>Rice seeds are able to germinate under water, also thanks to their ability to produce α-amylase under O₂ shortage, thus allowing starch degradation. Calcineurin B-like interacting protein kinase 15 (CIPK15) was previously identified as a positive regulator of α-amylase induction during anaerobic germination. In this study, we describe calcineurin B-like proteins 4 (CBL4) as a CIPK15 partner under low O₂.</p>
<p>Metabolomics analysis of postphotosynthetic effects of gaseous O₂ on primary metabolism in illuminated leaves <i>Cyril Abadie, Sophie Blanchet, Adam Carroll and Guillaume Tcherkez</i></p>	929–940	<p>Leaf gas exchange is commonly manipulated using low O₂ to suppress photorespiration but the detailed effects of this condition on leaf metabolism have often been disregarded. In this study, we used metabolomics to show metabolic alterations typical of a hypoxic response and that the aspartate pathway, including methionine synthesis, is sensitive to the O₂ mole fraction. These results provide evidence that, contrary to common belief, leaf catabolism and biosyntheses are sensitive to gaseous conditions.</p>
<p>Plant ionic relation and whole-plant physiological responses to waterlogging, salinity and their combination in barley <i>Zhinous Falakboland, Meixue Zhou, Fanrong Zeng, Ali Kiani-Pouya, Lana Shabala and Sergey Shabala</i></p>	941–953	<p>This work investigated physiological mechanisms conferring barley adaptation to combined waterlogging and salinity stress. Plants exposed to combined stress showed a negative correlation between shoot Na⁺ accumulation and the extent of salinity damage. Overall, the reported results indicated that K⁺ reduction in the plants but not stress-induced Na⁺ accumulation in the shoot was the most critical feature determining the overall plant performance under combined stress conditions.</p>