

Functional Plant Biology

Contents

Volume 36 Issue 10/11 2009

Special Issue: Plant Phenomics

Foreword: Plant phenomics: from gene to form and function

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<p>C₄ rice: a challenge for plant phenomics Robert T. Furbank, Susanne von Caemmerer, John Sheehy and Gerry Edwards 845–856</p>	<p>A major international effort has begun to identify and engineer the genes necessary to install a C₄ photosynthetic mechanism in rice to provide a quantum increase in yield. This paper describes phenomics approaches to quantitatively measure 'C₄-ness' for identification of C₃ plants that have gained C₄-like function or C₄ plants that have lost key components of the C₄ mechanism.</p>
<p>Non-destructive measurement of chlorophyll <i>b</i>:<i>a</i> ratios and identification of photosynthetic pathways in grasses by reflectance spectroscopy Katharina Siebke and Marilyn C. Ball 857–866</p>	<p>Relationships between reflectance spectra and chlorophyll composition were studied in barley mutants with low chlorophyll <i>b</i> contents and 23 other grasses. Equations were developed that linked features of the spectra affected by chlorophyll absorption to the Chl <i>b</i>:<i>a</i> ratio, and features affected by chlorophyll fluorescence to C₃ and C₄ photosynthetic pathways.</p>
<p>Chlorophyll fluorescence screening of <i>Arabidopsis thaliana</i> for CO₂ sensitive photorespiration and photoinhibition mutants Murray R. Badger, Hossein Fallahi, Sarah Kaines and Shunichi Takahashi 867–873</p>	<p>An innovative high throughput chlorophyll fluorescence imaging technique, using the dark adapted F_v/F_m parameter, is used to identify <i>Arabidopsis</i> mutants which are impaired in the efficient utilization of low and high CO₂. This technique has the potential to isolate new mutants defective in various aspects of photorespiration and photoinhibition.</p>
<p>3D monitoring spatio-temporal effects of herbicide on a whole plant using combined range and chlorophyll <i>a</i> fluorescence imaging Atsumi Konishi, Akira Eguchi, Fumiki Hosoi and Kenji Omasa 874–879</p>	<p>Spatio-temporal effects of herbicide, including DCMU, on a whole plant were 3D monitored using combined range and chlorophyll fluorescence imaging. The results indicated that differences in uptake and effects of herbicide in the plant from soil depend on the structural parameters of leaves and microenvironments as well as leaf age.</p>
<p>Chlorophyll fluorescence imaging as tool for understanding the impact of fungal diseases on plant performance: a phenomics perspective Julie D. Scholes and Stephen A. Rolfe 880–892</p>	<p>The potential of chlorophyll fluorescence imaging in high throughput phenomics screens were examined to: detect the presence of fungal diseases before the appearance of visible symptoms, distinguish between compatible and incompatible interactions, identify heterogeneity in photosynthetic performance and provide insights into the underlying metabolic changes in infected leaves.</p>

Cover illustration: (left) 3D chlorophyll fluorescence imaging of melon plants to assess herbicide damage (see Konishi *et al.* pp. 874–879) and (right) infrared thermography of barley seedlings to screen for osmotic stress tolerance. The plant on the left, labelled Sp2, has been subjected to 100 mM salt (see Sirault *et al.* pp. 970–977).

<p>Feedback limitation of photosynthesis at high CO₂ acts by modulating the activity of the chloroplast ATP synthase Olavi Kuirats, Jeffrey A. Cruz, Gerald E. Edwards and David M. Kramer</p>	893–901	<p>Previous work has shown that the ATP synthase plays a major role in regulation of the light reactions of photosynthesis under low CO₂. Here, we demonstrate a similar role under when photosynthesis is limited downstream of assimilation. We propose that the ATP synthase co-regulates both the light reactions, by modulating proton efflux from the thylakoid lumen, as well as the Benson–Calvin cycle and starch biosynthesis, by regulating the uptake of inorganic phosphate.</p>
<p>Simultaneous phenotyping of leaf growth and chlorophyll fluorescence via GROWSCREEN FLUORO allows detection of stress tolerance in <i>Arabidopsis thaliana</i> and other rosette plants Marcus Jansen, Frank Gilmer, Bernhard Biskup, Kerstin A. Nagel, Uwe Rascher, Andreas Fischbach, Sabine Briem, Georg Dreissen, Susanne Tittmann, Silvia Braun, Iris De Jaeger, Michael Metzloff, Ulrich Schurr, Hanno Scharr and Achim Walter</p>	902–914	<p>Dynamic changes of leaf growth, leaf shape and the potential quantum yield of PSII were monitored simultaneously using a novel approach based on existing imaging technology. The drought stress reaction of more than 500 plants revealed subtle differences between the performances of different genotypes. Similar experiments were conducted in chilling stress and with altered UV-B illumination demonstrating the capability of this approach.</p>
<p>Transposon-based activation tagging in cereals M. A. Ayliffe and A. J. Pryor</p>	915–921	<p>An activation tagging system has been developed in barley based upon a synthetic maize transposable element that encodes two highly expressed promoter elements. Insertion of this sequence into cereal genomes can lead to gene over expression, gene silencing and gene knockout mutations.</p>
<p>Root phenomics of crops: opportunities and challenges Peter J. Gregory, A. Glyn Bengough, Dmitri Grinev, Sonja Schmidt, W. (Bill) T. B. Thomas, Tobias Wojciechowski and Iain M. Young</p>	922–929	<p>Phenotyping roots of large numbers of plants in anything other than simple media such as agar or nutrient solution is still challenging. Agar plates may also give different phenotypes than the same cultivar grown in soil. X-ray tomography permits screening in soil of a small number of plants per day.</p>
<p>The use of green fluorescent protein as a tool to identify roots in mixed plant stands Marc Faget, Juan M. Herrera, Peter Stamp, Ingrid Aulinger-Leipner, Emmanuel Frossard and Markus Liedgens</p>	930–937	<p>Transgenic plants expressing fluorescent proteins, in the present case maize (<i>Zea mays</i> L.), combined with the minirhizotron technique, will contribute to overcome limitations for studying roots of plants growing in mixture, as demonstrated for combinations with the corresponding wild type maize, Italian ryegrass (<i>Lolium multiflorum</i> Lam.) and soybean (<i>Glycine max</i> (L.) Merr.).</p>
<p>High throughput phenotyping of root growth dynamics, lateral root formation, root architecture and root hair development enabled by PlaRoM Nima Yazdanbakhsh and Joachim Fisahn</p>	938–946	<p>Here we describe a range of applications of a recently developed plant root monitoring platform (PlaRoM), which is developed for multi parallel recordings of root elongation of up to 50 individual seedlings growing in various conditions (e.g. light protocol, temperature, growth media) over several days, with high spatial and temporal resolution.</p>
<p>Temperature responses of roots: impact on growth, root system architecture and implications for phenotyping Kerstin A. Nagel, Bernd Kastenholz, Siegfried Jahnke, Dagmar van Dusschoten, Til Aach, Matthias Mühlich, Daniel Truhn, Hanno Scharr, Stefan Terjung, Achim Walter and Ulrich Schurr</p>	947–959	<p>Root phenotyping is a challenging task due to the hidden nature of this organ. The presented integrated approach of combining different phenotyping technologies allows to elucidate the dynamic establishment of root system architecture and to connect differences between genotypes obtained in artificial high throughput conditions with specific characteristics relevant for field performance.</p>

<p>The shoot and root growth of <i>Brachypodium</i> and its potential as a model for wheat and other cereal crops Michelle Watt, Katharina Schneebeli, Pan Dong and Iain W. Wilson</p>	960–969	<p>This paper describes the shoot and root development of the newly sequenced grass model <i>Brachypodium</i>, demonstrating that it is an excellent phenotypic model for wheat and cereal crops. <i>Brachypodium</i> advantages include a small size and fast life cycle, allowing the genetics of mature root system growth and function to be discovered faster in future.</p>
<p>A new screening method for osmotic component of salinity tolerance in cereals using infrared thermography Xavier R. R. Sirault, Richard A. James and Robert T. Furbank</p>	970–977	<p>Osmotic stress is the major caused of reduced growth rate of plants in saline soils. A high-throughput, automated image analysis protocol for the capture and analysis of thermal images was developed to quantify the osmotic stress response of wheat and barley genotypes known to vary for osmotic stress tolerance.</p>
<p>Thermal infrared imaging of crop canopies for the remote diagnosis and quantification of plant responses to water stress in the field Hamlyn G. Jones, Rachid Serraj, Brian R. Loveys, Lizhong Xiong, Ashley Wheaton and Adam H. Price</p>	978–989	<p>Thermal imaging provides a powerful new tool for remote diagnosis and quantification of water stress. This paper outlines recent developments in its application to drought phenotyping and irrigation control in the field, concentrating on a description of the main limitations of the approach and the precautions that are necessary.</p>
<p>An infrared-based coefficient to screen plant environmental stress: concept, test and applications Guo Yu Qiu, Kenji Omasa and Sadanori Sase</p>	990–997	<p>An infrared applicable plant transpiration transfer coefficient was tested to monitor environmental stress caused by water shortage and high temperature on melon, tomato and lettuce plants under various conditions. Results showed that the proposed coefficient was reasonable and plant environmental stress could be quantitatively monitored by using it.</p>
<p>Detecting seasonal change of broad-leaved woody canopy leaf area density profile using 3D portable LIDAR imaging Fumiki Hosoi and Kenji Omasa</p>	998–1005	<p>Vertical leaf area density (LAD) profiles of woody canopy broad-leaved trees for different seasons were estimated using 3D portable scanning LIDAR imaging. The results clearly showed the seasonal change of LAD. Moreover, leaf inclination angle (LIA) distributions were also derived using the LIDAR imaging. The results showed the distinctive features of LIA in each season.</p>
<p>Near-distance imaging spectroscopy investigating chlorophyll fluorescence and photosynthetic activity of grassland in the daily course Alexander Ač, Zbyněk Malenovský, Jan Hanuš, Ivana Tomášková, Otmar Urban and Michal V. Marek</p>	1006–1015	<p>The core of this manuscript is the detection of the chlorophyll fluorescence (Chl-<i>F</i>) signal under natural light conditions, using airborne imaging spectrometer. Ground-based hyperspectral reflectance measurements were coupled to a leaf-level chlorophyll content and chlorophyll fluorescence measurements. This study provides further evidence, that Chl-<i>F</i> signal is extractable from remote sensing data, with potentially useful and quantitative information on functioning of the photosynthetic apparatus.</p>
<p>Biochemical constrains limit the potential of the photochemical reflectance index as a predictor of effective quantum efficiency of photosynthesis during the winter spring transition in Jack pine seedlings Florian Busch, Norman P. A. Hüner and Ingo Ensminger</p>	1016–1026	<p>This study examines the relationship between the photochemical reflectance index (PRI) and the effective photochemical quantum efficiency (Φ_{II}) during the winter to spring transition of cold-acclimated Jack pine seedlings. PRI, which was mostly affected by light intensity, could not explain the variation in the temperature dependent Φ_{II}, underlining the importance of a proper understanding of different energy quenching mechanisms.</p>