Bioenergy Crops in Annals of Botany

Rapid progress has been made over the last five years with respect to emerging new genomic technologies for crop improvement and this *Annals of Botany Special* Issue will be devoted to highlighting the latest findings and considering the potential of these technologies for the future deployment of bioenergy crops in the face of climate change. At the same time, cutting-edge research that provides insights into the complex plant traits underpinning drought tolerance and response to other abiotic and biotic stresses is required for these relatively new crops. Knowledge in this area will be brought together, with a focus on recent advances in high throughput phenotyping to unravel the complex responses.

The *Annals of Botany* Special Issue will cover:

- The changing climate, the availability of land, biomass supply and emergence of BECCS
- Complex phenotypes for future climates; drought tolerance and responses to multiple biotic and abiotic stresses
- Bioengineering progress in lignocellulosics crops and future prospects
- Predictive modelling for yield and approaches to integrate genomic and phenomic data
- New genomic technologies for capturing wide genetic variation and their value to breeding in lignocellulosic crops

Special Issue on Developing sustainable bioenergy crops for future climates

Publication due Spring 2019

Deadline for Submissions: 16 April 2018

Primary research, reviews, viewpoints, and research-in-context articles are welcomed.

Please send an outline proposal by 1 February 2018 to office@annbot.com

Guest Editors: Rishi Bhalerao, Bill Davies, Iain Donnison, Antoine Harfouche, Joost Keurentjes, Michele Morgante, Donal Murphy-Boekern, Steve Long, Andrea Polle, Andrew Smith and Gail Taylor

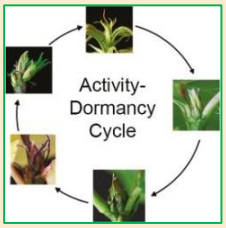
Highlighted recent publications

Genetics of phenotypic plasticity and biomass traits in hybrid willows

Annals of Botany 120: 87–100, 2017
doi: 10.1093/aob/mcx029

Phenotypic plasticity can have a great impact on the distribution of taxa and the productivity of crops across contrasting environments. **Berlin *et al.*** study the genetic architecture of biomass traits, including phenotypic plasticity in an experimental hybrid willow (*Salix*) population. The population was planted over three common garden experiments, comprising one climatic contrast between Sweden and Italy and one water availability contrast in Italy. Compared to phenological traits, the genetic regulation of biomass traits was highly sensitive to the climate. These important findings demonstrate that breeding systems should be adapted according to climate in order to maximise biomass production in willows.

Authors: S. Berlin, H.R. Hallingbäck, F. Beyer, N-E. Nordh, M. Weih and A. C. Rönnberg-Wästljung



Molecular mediation of photoperiodic control in activity-dormancy tree growth cycles (Invited Review)

Annals of Botany 120: 351-360, 2017
doi: 10.1093/aob/mcx061

Plants residing in temperate and boreal regions undergo annual activity-dormancy cycles in order to cope with the extreme variations in climate that accompany changes in seasons. Photoperiod and temperature signals act as the key environmental cues controlling growth cessation and dormancy. **Maurya and Bhalerao** highlight data indicating that symplastic communication may mediate certain aspects of seasonal growth; the results point to a high level of conservation in the signalling pathways that mediate photoperiodic control of seasonal growth in trees and flowering in annual plants such as Arabidopsis. This review article suggests that the future challenge is extending these insights into the control of phenology in model plants such as poplar and spruce by applying a similar framework to other, non-model trees.

Authors: Jay Maurya and Rishikesh Bhalerao

Seedling root architectural traits associated with yield in wheat

Annals of Botany 119: 1115-1129, 2017
doi: 10.1093/aob/mcx001

Roots, the 'hidden half' of plants, are notoriously difficult to phenotype. **Xie *et al.*** utilise a 'pouch and wick' high-throughput phenotyping pipeline to quantify the variation in seedling root system architecture of bread wheat (*Triticum aestivum*) × spelt (*Triticum spelta*) recombinant inbred line population. Seminal root number and total root length are both positively associated with grain number, above-ground biomass and grain yield at maturity in field, likely resulting from tightly linked genes or pleiotropy. Vigorous early root growth is correlated with improved yield potential. These results have significant implications for wheat breeding.

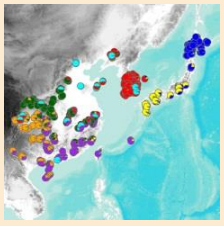
Authors: Quan Xie, Kurukulasuriya Fernando, Sean Mayes and Debbie Sparkes

Brachypodium peroxidase and drought tolerance

Annals of Botany 118: 259-270, 2016
doi: 10.1093/aob/mcw104

The peroxidase (POD) family shows functional diversity. **Luo *et al.*** demonstrate that *Brachypodium distachyon* ecotypes have distinct specific POD isozymes. Two *POD* genes are closely associated with whole-plant response to drought, which may lead to natural variations of drought tolerance. The role of specific *POD* genes in differentiating *Brachypodiu*m accessions with contrasting drought tolerance could be associated with the general fitness of *B. distachyon* during evolution.

Authors: Na Luo, Xiaoqing Yu, Gang Nie, Jianxiu Liu, and Yiwei Jiang

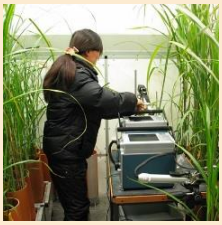


Past climate change and population structure of *Miscanthus*

Annals of Botany 114: 97-107, 2014
doi: 10.1093/aob/mcu084

Miscanthus sinensis is a perennial C_4 grass that is one parent of the economically important hybrid biomass species, *M.* × *giganteus*. **Clark *et al.*** evaluate 620 *M. sinensis* accessions from most of its native range with >20 000 nuclear and plastid markers, and identify six genetic groups. They find that coastal south-east China was a refugium of *M. sinensis* during the last glacial maximum, and that the species recolonized Japan prior to recolonizing similar latitudes in mainland Asia. Ornamental cultivars originate almost exclusively from southern Japan, and many marketed as *M. sinensis* have hybrid ancestry from *M. sacchariflorus*.

Authors: Lindsay Clark, Joe Brummer, Katarzyna Głowacka, Megan . Hall, Kweon Heo, Junhua Peng, Toshihiko Yamada, Ji Hye Yoo, Chang Yeon Yu, Hua Zhao, Stephen Long, and Erik. Sacks



Gas exchange measurements on *Miscanthus* leaves

Annals of Botany 117: 1229-1239, 2016
doi: 10.1093/aob/mcw042

Miscanthus has a high yield potential, but even though it is less cold sensitive than other C_4 species, it emerges later in spring than C_3 species. **Jiao *et al.*** identified one *Miscanthus sacchariflorus* with a level of cold tolerance similar to *Miscanthus* × *giganteus*. They also found a positive linear correlation between net photosynthesis and shoot growth rate as well as specific leaf area. These are relatively easy to measure and useful for the screening of productivity and cold tolerance. The *Miscanthus* genotype with high cold tolerance can be useful for breeding of new interspecies hybrids or cultivation in temperate climates.

Authors: Xiurong Jiao, Kirsten Kørup, Mathias Neumann Andersen, Karen Koefoed Petersen, Thomas Prade, Stanisław Jezowski, Szymon Ornatowski, Barbara Gorynowicz, Idan Spitz, Poul Erik Lærke, and Uffe Jørgensen

Water stress, xylem hydraulic failure and tree death

Annals of Botany 112: 1431-1437, 2013
doi: 10.1093/aob/mct204

Extreme water stress episodes induce tree mortality, but the mechanistic relationships linking stem embolism and species drought performance remain poorly understood. **Barigah *et al.*** study potted juvenile trees of beech (*Fagus sylvatica*) and poplar (*Populus deltoides* × *P. nigra*) and find that the xylem pressure inducing 50 % mortality differs sharply between the species, being 1·75 and 4·5 MPa in poplar and beech, respectively. However, the relationships between tree mortality and the degree of cavitation in the stems are similar, with mortality occurring suddenly when >90 % cavitation has occurred. This is in contrast to the 50 % embolism threshold reported for conifers. The results demonstrate that massive cavitation is probably a causal factor for tree mortality under extreme water stress conditions.

Authors: Marc Bonhomme, Stéphane Herbette, Thierry Améglio, Régis Fichot, Frank Brignolas, and Hervé Cochard

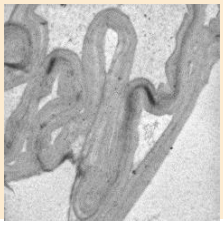
Bioenergy Crops in Annals of Botany

Variation of cell wall properties in *Miscanthus*

Annals of Botany 114: 1256-1277, 2014
doi: 10.1093/aob/mcu054

Miscanthus represents one of the most promising dedicated lignocellulosic bioenergy crops. A key trait for biomass conversion to biofuels and biomaterials is cell wall quality. **Costa *et al.*** present data on cell wall compositional changes as a function of development and tissue type across 25 selected *Miscanthus* genotypes. They report compositional differences between stem and leaf samples to be predominantly associated with structural carbohydrates, while lignin content does not correlate with ethanol production from leaf biomass. Overall, leaf tissue contributes significantly to total above-ground biomass at all developmental stages. These factors highlight the importance of examining leaf and stem biomass composition separately in order to infer gene–trait associations relating to cell wall quality of lignocellulosic biomass.

Authors: Ricardo da Costa, Scott Lee, Gordon Allison, Samuel Hazen, Ana Winters, and Maurice Bosch



Sugarcane roots and cell wall changes during aerenchyma formation

Annals of Botany 120: 693-708, 2017
doi: 10.1093/aob/mcx050

Intercellular gas-conducting spaces, known as aerenchyma, facilitate the transport of volatile substances within plants. Aerenchyma tissues consist of interconnected channels that enable transmission conduction of gases such as oxygen and ethylene, conferring tolerance to flooding. Even when constituted of such gaps, organs such as roots still maintain their mechanical properties. Using sugarcane roots as a model, **Leite *et al.*** document cell walls changes during aerenchyma development. The first event of cell wall separation occurs when degradation of one of the hemicelluloses causes cells to expand and enter programmed cell death. Subtle cell wall modifications then take place in the walls of the aerenchyma forming cells, giving rise to a composite made of cellulose and hemicelluloses that surrounds the inner side of the cavities, which becomes the vehicle for transporting volatile substances throughout the root.

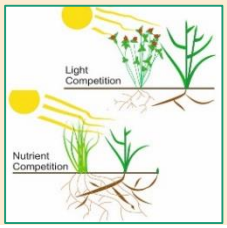
Authors: D. C. C. Leite, A. Grandis, E. Q. P. Tavares, A. R. Piovezani, S. Pattathil, U. Avici, A. Rossini, A. B. Cambler, A. P. De Souza, M. G. Hahn, and M. S. Buckeridge

Gas exchange measurements on *Miscanthus* leaves

Annals of Botany 118: 941-955, 2016
doi: 10.1093/aob/mcw137

Miscanthus is a genus of C_4 perennial East Asian grasses that is emerging as a leading bioenergy crop. **Clark *et al.*** collected germplasm of *M. sacchariflorus* and *M. sinensis* in the Russian Far East, at the northern extent of the range of these two species. Geographic distributions suggest greater winter hardiness in *M. sacchariflorus* than in *M. sinensis*. Accessions were genotyped using restriction site associated DNA sequencing (RAD-seq) and a preliminary genome-wide association (GWA) analysis was performed to identify biomass traits in *M. sacchariflorus*. The data highlights the value of phenotypic data obtained *in situ* during germplasm collection and will have implications for breeding *Miscanthus* and sugarcane cultivars with improved adaptation to cold. The authors propose a strategy to facilitate the rapid utilisation of new germplasm collections by implementing low-cost SNP genotyping to conduct GWA analysis of phenotypic data obtained at collection sites, with the aim of providing plant breeders with actionable information on desirable traits and alleles found in accessions.

Authors: Lindsay Clark, Elena Dzyubenko, Nikolay Dzyubenko, Larisa Bagmet, Andrey Sabitov, Pavel Chebukin, Douglas Johnson, Jens Bonderup Kjeldsen, Karen Koefoed Petersen, Uffe Jørgensen, Ji Hye Yoo, Kweon Heo, Chang Yeon Yu, Hua Zhao, Xiaoli Jin, Junhua Peng, Toshihiko Yamada, and Erik Sacks



Light competition suppresses couch grass more efficiently than nutrient competition

Annals of Botany 119: 477-485, 2017
doi: 10.1093/aob/mcw228

Competitive crops are important for sustainable cropping systems. For perennial weeds, below-ground organs, for instance rhizomes for couch grass, constitute the best measure of a crop's long term suppressive capabilities. **Ringselle *et al.*** found that the type of competition (primarily for light or nutrients) utilised by a crop influences both the suppression rate and the likelihood of whether the crop will successfully alter the weed's allocation pattern. By competing primarily for light, red clover suppressed the rhizome biomass of couch grass more than perennial ryegrass per gram of produced companion crop biomass. Perennial ryegrass impacted upon couch grass allocation with a higher proportion of rhizomes.

Authors: Björn Ringselle, Inés Prieto-Ruiz, Lars Andersson,, Helena Aronsson, and Göran Bergkvist

Chilling tolerance of C4 photosynthesis in *Miscanthus*

Annals of Botany 115: 981-990, 2015
doi: 10.1093/aob/mcv035

A clone of the hybrid perennial C_4 grass *Miscanthus* × *giganteus* (Mxg) is known for achieving exceptionally high rates of leaf CO_2 uptake during chilling. **Głowacka *et al.*** study accessions from Japanese populations of *M. sacchariflorus*, *M. sinensis* and *M. tinctorius* whose leaves survived a natural late frost in the field and screen them for high maximum photosystem II efficiency following chilling weather. They find relatives of Mxg with significantly superior capacity for photosynthesis at chilling temperatures, apparently for the first time. As well as identifying important material for breeding new synthetic *M.* × *giganteus* with a greater capacity for photosynthesis under chilling conditions, the results add further proof to the thesis that C_4photosynthesis is not inherently limited to warm climates.

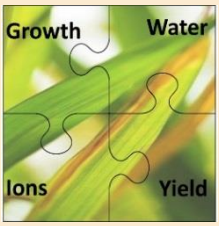
Authors: Katarzyna Głowacka, Uffe Jørgensen, Jens Kjeldsen, Kirsten Kørup, Idan Spitz, Erik Sacks, and Stephen Long

Whole-plant organisational traits and ecological strategies in sunflowers

Annals of Botany 119: 1131-1142, 2017
doi: 10.1093/aob/mcx002

While trait-based plant ecology attempts to use small numbers of organ-level traits to predict ecological strategies, there is a major gap between organ-level ecophysiology and plant fitness in an environmental context. Bridging this gap are whole-plant organisational traits, including reproductive timing and biomass allocation patterns. **Mason *et al.*** explore the role of these traits in adaptation to diverse environments, using a phylogenetic comparative approach across wild sunflower species (*Helianthus*). Whole-plant organisational traits are shown to be just as important as organ-level traits in predicting ecological strategies in sunflowers, demonstrating that trait-based ecology can be strengthened through the explicit inclusion of whole-plant organisation.

Authors: Chase Mason, Eric Goolsby, Kaleigh Davis, Devon Bullock, and Lisa Donovan



Evaluating traits contributing to salinity tolerance (Viewpoint)

Annals of Botany 119: 1-11, 2017
doi: 10.1093/aob/mcw191

Salinity stress impacts myriad aspects of a plant's function, with potentially catastrophic results for crop yield. As an alternative to studying overall salinity tolerance according to physiological effects, **Negrão *et al.*** recommend a trait-based approach to identifying salinity-induced plant responses. In this Viewpoint, the authors present methods and support methodologies to test for and quantify the impact of salinity on individual traits, such as ion exclusion, maintenance of water relations, transpiration rate and efficiency, ionic relations, photosynthesis, senescence, and maintenance of growth and yield components.

Authors: S. Negrão, S. M. Schmöckel, and M. Tester

Articles in press

Optimizing soil-coring strategies to quantify root-length-density distribution in field-grown maize: virtual coring trials using 3-D root architecture models

Annals of Botany, 2018 doi: 10.1093/aob/mcx117
Authors: Qian Wu; Jie Wu; Bangyou Zheng; Yan Guo

Physiological basis of chilling tolerance and early-season growth in *Miscanthus*

Annals of Botany, 2018 doi: 10.1093/aob/mcx159
Authors: Simon Fonteyne; Hilde Muylle; Peter Lootens; Pavel Kerchev; Wim Van den Ende, Ariane Staelens Dirk Reheul, and Isabel Roldán-Ruiz

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