

Functional Plant Biology

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Special Issue: Crops for a Future Climate

Foreword: Crops for a future climate
Roslyn Gleadow, Alexander Johnson
and Michael Tausz iii–vi

Enhancing the chelation capacity of rice to maximise iron and zinc concentrations under elevated atmospheric carbon dioxide
Alexander A. T. Johnson

101–108

Rising atmospheric carbon dioxide concentrations [CO₂] will cause a multitude of physiological and nutritional changes to rice, one of the most important food crops in the world. Here I review these changes, focusing on the expected decreases in grain nutritional quality and identify stimulation of the Strategy II iron uptake pathway as a promising strategy to increase iron and zinc concentrations in rice grain under ambient and elevated [CO₂]. These results may be applicable to other Strategy II crops such as maize, wheat and barley.

Optimal crop canopy architecture to maximise canopy photosynthetic CO₂ uptake under elevated CO₂ – a theoretical study using a mechanistic model of canopy photosynthesis
Qingfeng Song, Guilian Zhang
and Xin-Guang Zhu

109–124

Crop yields are more related to canopy photosynthesis instead of leaf photosynthesis. This study established a mathematical model to link canopy architectural and biochemical parameters to total canopy CO₂ uptake rate and explored the optimal canopy architectural parameters for elevated CO₂ conditions. This new canopy photosynthesis model can help design crops to optimize canopy photosynthesis under different environments.

Pest and disease abundance and dynamics in wheat and oilseed rape as affected by elevated atmospheric CO₂ concentrations
Viktoriya Oehme, Petra Högy, Jürgen Franzaring,
Claus P. W. Zebitz and Andreas Fangmeier

125–136

Future atmospheric carbon dioxide levels are likely to double in concentration, affecting agricultural crops, herbivorous insects and the possible progression of various plant diseases. The abundance of insects significantly changed under elevated CO₂ in our study, whereas plant characteristics (phenology, aboveground biomass, foliar nitrogen and carbon contents) and development of fungal plant pathogens did not.

Minirhizotron imaging reveals that nodulation of field-grown soybean is enhanced by free-air CO₂ enrichment only when combined with drought stress
Sharon B. Gray, Reid S. Strellner,
Kannan K. Puthuval, Christopher Ng,
Ross E. Shulman, Matthew H. Siebers,
Alistair Rogers and Andrew D. B. Leahey

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Future food supply from legume crops, such as soybean, will depend on how rising atmospheric carbon dioxide concentrations and drought alter the formation of root nodules in which atmospheric nitrogen is captured. Soybean grown under drought and elevated carbon dioxide produced two to three times more nodules, but that nevertheless overall nitrogen capture by the plants decreased. This was caused by development of nodules in the driest soil layers, and indicates that soybean will be more negatively impacted by global environmental change than previously thought.

Cover illustration: Wheat growing under increased atmospheric CO₂ in the Australian Grains Free Air CO₂ Enrichment (AGFACE) facility in a low rainfall cropping area in Horsham, Victoria, Australia. AGFACE is jointly run by the University of Melbourne and the Victorian Department of Primary Industries and supported by The Australian Commonwealth Department of Agriculture, Fisheries and Forestry and the Grains Research and Development Corporation. Photograph by Sabine Tausz-Posch.

<p>Rice cultivar responses to elevated CO₂ at two free-air CO₂ enrichment (FACE) sites in Japan Toshihiro Hasegawa, Hidemitsu Sakai, Takeshi Tokida, Hirofumi Nakamura, Chunwu Zhu, Yasuhiro Usui, Mayumi Yoshimoto, Minehiko Fukuoka, Hitomi Wakatsuki, Nobuko Katayanagi, Toshinori Matsunami, Yoshihiro Kaneta, Takashi Sato, Fumiaki Takakai, Ryoji Sameshima, Masumi Okada, Tadahiko Mae and Amane Makino</p>	148–159	<p>Opportunities exist for improving rice productivity under future CO₂ concentrations. We examined intraspecific variation in yield responses to free-air CO₂ enrichment (FACE) treatments at two sites in Japan, differing in growing-season mean air temperatures by 5°C. Yield enhancements due to elevated CO₂ differed largely between cultivars ranging from 3 to 36%. A large sink is an effective trait for higher productivity under elevated CO₂ at both sites.</p>
<p>Can elevated CO₂ combined with high temperature ameliorate the effect of terminal drought in wheat? Eduardo Dias de Oliveira, Helen Bramley, Kadambot H. M. Siddique, Samuel Henty, Jens Berger and Jairo A. Palta</p>	160–171	<p>Wheat may have different responses to future climates in Australia. Grain yield and biomass under elevated CO₂ increased when the temperature was 2°C higher than the ambient, regardless of irrigation or terminal drought, but not when temperatures were >2°C higher than the ambient. The interaction of elevated CO₂ × temperature × drought should be considered in the new generation of studies on crop adaptation to future climates in Australia.</p>
<p>Genotypic variability in the response to elevated CO₂ of wheat lines differing in adaptive traits Maryse Bourgault, M. Fernanda Dreccer, Andrew T. James and Scott C. Chapman</p>	172–184	<p>Elevated CO₂ increases wheat yields, but the variability in response suggests that some lines might respond better than others. We specifically chose lines that we know differ in various adaptive traits, some which might have limited the response to elevated CO₂, and found that all lines responded in the same manner. This suggests that the current breeding effort for drought tolerance will not reduce the response to elevated CO₂.</p>
<p>Intraspecific variation in growth and yield response to elevated CO₂ in wheat depends on the differences of leaf mass per unit area Chamindathee L. Thilakarathne, Sabine Tausz-Posch, Karen Cane, Robert M. Norton, Michael Tausz and Saman Seneweera</p>	185–194	<p>Optimisation of plant responses to increasing CO₂ is a key strategy to achieve future food security. Identification of the leaf level traits that can capture the CO₂ response will be easily adopted for the future wheat breeding programs. This work demonstrates the genetic capacity to adjust the leaf level traits, such as leaf mass per area and leaf nitrogen status to capture the CO₂ response.</p>
<p>Drought adversely affects tuber development and nutritional quality of the staple crop cassava (<i>Manihot esculenta</i> Crantz) Rebecca Vandeger, Rebecca E. Miller, Melissa Bain, Roslyn M. Gleadow and Timothy R. Cavagnaro</p>	195–200	<p>Cassava is a staple for over 850 million people, but it is toxic unless properly processed. A monotonous cassava diet often coincides with outbreaks of diseases such as konzo, especially during droughts. The concentration of cyanogenic glucosides in young tubers was 4-fold higher when plants were water stressed, but was lower following re-watering. We conclude that any expansion of cassava into new areas must be accompanied by knowledge of appropriate methods for detoxification, especially in areas increasing in aridity due to climate change.</p>
<p>Impact of industrial-age climate change on the relationship between water uptake and tissue nitrogen in eucalypt seedlings Gyro L. Sherwin, Laurel George, Kamali Kannangara, David T. Tissue and Oula Ghannoum</p>	201–212	<p>Seedlings of <i>Eucalyptus saligna</i> Sm. were grown under three CO₂ concentrations (280, 400 or 640 µL L⁻¹) and two air temperatures (current or current + 4°C). Total plant N uptake scaled with total water use and root biomass across all treatments, suggesting that reductions in tissue N concentration may be attributed to changes in root N uptake by mass flow due to altered transpiration rates.</p>