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Editorial

Bioenergy Plants: Hopes, Concerns and Prospectives

There are major concerns over both the security of energy supplies (declining supplies and political control) and the environmental costs associated with energy generation and use. The global consumption of carbon-containing fossil fuels for heat, electricity, transport and the manufacture of chemicals is not sustainable. This has promulgated a great interest in various forms of renewable energy and the imposition, in some countries, of targets and legislation for mitigating climate change. Bioenergy can contribute to energy security whilst also decreasing the emissions of carbon dioxide (CO_2) from fossil fuels. Life cycle analysis suggests that some of the bioenergy crops do not decrease the emissions of CO_2 from fossil fuels and that they are used primarily to meet political targets (Carroll and Sommerville 2009; Walker 2010). Furthermore, the use of food crops (wheat and maize) for bioenergy has engendered great concern over their impact on global food security (Parry and Hawkesford 2010). This direct impact on food supply will be exacerbated if land previously used for food production is used for bioenergy crops, by further urbanization and land degradation. However, some bioenergy crops have comparatively low resource requirements and can be grown on marginal or contaminated land that is not suitable for food crop production. Globally, the production of both food and bioenergy is projected to decrease as a consequence of increasing temperatures and lower, more erratic rainfall (IPCC 2007 http://www.ipcc.ch/).

It is essential to identify sustainable sources of bioenergy and biofuels. The two serial special issues of *Journal of Integrative Plant Biology* examine the resources, prospects and opportunities for bioenergy. The breeding strategies which have been successfully applied to food crops can and are being applied to bioenergy crops. An increasing number of species have been identified as potential bioenergy crops (Mariani et al. 2010).

In these two serial issues, 12 invited reviews and research articles as well as a meeting report are presented, addressing the genetic diversity and variation of bioenergy plants, the regulation of bioenergy-associated traits, and the development of high-throughput tools and platforms. The second serial issue will be published in issue 3, 2011. These papers are contributed by research groups that are currently active in the field and reflect their latest knowledge advances. At the moment, grass species are often the crops of choice for the development of sugar-based and lignocellulosic bioenergy as described in the meeting report from the 2nd International Symposium on Bioenergy and Biotechnology, which was held on October 16–19th, 2010 at Huazhong Agricultural University, Wuhan, China (Peng and Gutterson 2011). A review by Sang (2011) takes a unique angle to examine how to improve bioenergy associated traits and suggests lessons learnt from food crop domestication may help. Bioenergy research can benefit from high through-put, low cost sequencing technology and the rapidly increasing number of whole-genome sequences. Vermerris (2011) highlights how genomics, genetic mapping, forward and reverse genetics can be used to unravel and improve bioenergy crops and traits, particularly in the C_4 grasses, whereas the importance to understand rice cell wall compositions and to make crop straw residues more amendable for biofuel production is addressed by Zhang and Zhou (2011) and Xie and Peng (2011). However, the key to increasing the biomass yield is the identification of the most important traits related to biomass production including early vigour, stay green, and tolerance to biotic and abiotic stresses (Byrt et al. 2011; Guo et al. 2011; Karp et al. 2011). Furthermore, traits related to the composition of biomass are important as these directly affect the bioenergy output from downstream processes, such as combustion, saccharification and fermentation (Wang et al. 2011a; Hou and Li 2011).

Although full-genome sequences are not available for some of the important energy crops, the synteny between bioenergy crops and those so-called “model species” that have been fully sequenced (eg. poplar; Tuskan et al. 2006), together with the availability of extensive cDNA sequences for bioenergy crops suggests that substantial progress can be made (Swaminathan et al. 2010). For example in issue 3 Zhao et al. (2011) demonstrate the transferability of microsatellite markers from *Brachypodium distachyon* to miscanthus. Genetic resources are already available for willows (eg. mapping populations; Karp et al. 2011). Yang et al. (2011) designed a customised oligonucleotide microarray to establish the expression profile during cassava tube development. Current liquid transportation biofuels are derived from canola (oilseed rape) oils, or ethanol derived from the fermentation of sucrose or cellulose, and

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alternative biofuel crops such as algae and jatropha (Wang et al. 2011b).

As reflected in these two issues, potential bioenergy plants are diverse, each may have unique niches and traits requiring further exploitation. It seems fair to say that there are no unified single bioenergy plants that can be developed to meet all the demands in different countries and we still need to develop an arsenal of bioenergy plants. However, we believe that using cutting edge biotechnology, genomics, as well as molecular genetics to dissect the underlying mechanisms of bioenergy-associated traits will certainly improve and accelerate the development of tailor-made bioenergy plants.

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