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Abstract

From evolution to biotechnology: the impacts of genetically modifying stomatal development

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Abstract:

Changes in climate, increasing human population and reducing arable land area will lead to significant challenges in producing enough food. Therefore, increasingly climate-resilient crops will be required; which ideally will produce higher yields in future climates. One way to improve crop resilience and yield is via alterations to tiny pores on the epidermis called stomata. These microscopic structures, which have been present on land plants for over 400 million years, are fundamental to both the success of land plants and the shaping of the terrestrial biosphere. Stomata therefore are a key structures for plant-environment interactions and are a key target for crop improvement. Consisting of pairs of guard cells surrounding a central pore, Stomata control gaseous diffusion into and out of the plant. Open stomata allow CO2 uptake, regulate water loss and permit a transpiration stream; enabling photosynthesis, plant cooling and nutrient uptake. Conversely, closed stomata restrict gaseous exchange (including water loss) and restrict certain pathogens from entering into the leaf. Over the longer term, plants can also alter stomatal development to more finely tune gaseous exchanges with the environment, and if necessary, tighten defenses against biotic attackers. Typically, plants with fewer stomata have improved drought tolerance and resistance to stomatal pathogens, but this may be accompanied by reduced CO2 and nutrient uptake, and reduced capacity for plant cooling. In recent times it has become possible to genetically modify a large number of different land plant model species. Here, I will outline the latest advances relating to how stomatal development and plant performance can potentially be altered via genetic alterations to stomata development across multiple plant species. First considering Arabidopsis thaliana and then onto the non-vascular land plant moss Physcomitrella patens, I will discuss how reducing stomatal density affects crop plant performance in a number of key species, including barley, rice and wheat. I will predominantly focus on how this has been achieved via the modulation of signaling peptides called Epidermal Patterning Factors (EPFs). By assessing results achieved thus far, I will identify both potential strengths and weaknesses of adjusting EPF signaling in a number of different species, and finishing by discussing future directions of this key research area

Biography:

Robert (Bobby) is currently a Global Challenge Research Fellow at the University of Sheffield. He holds a PhD in the Evolution and Molecular Biology of stomatal development, obtained from the University of Sheffield. His present role involves the screening of a wide-array of germplasm to identify cultivated rice varieties and or land races with alterations to stomata on the leaf epidermis. The overall remit of this role is to develop rice varieties with both increased salt and drought tolerance for cultivation in the Mekong Delta of Southern Vietnam. Prior to his present role, Bobby was the lead post-doctoral researcher on a Newton Fund Grant aimed at improving abiotic stress tolerance of rice by genetically manipulating stomatal development. He has spoken at an array of international conferences and has contributed to 8 peer-reviewed publications including in journals such as Nature Plants, Plant Physiology and the New Phytologist.

Publication of speakers:

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2. Caine, R. S., Yin, X., Sloan, J., Harrison, E. L., Mohammed, U., Fulton, T., Biswal, A. K., Dionora, J., Chater, C. C., Coe, R. A., et al. (2019). Rice with reduced stomatal density conserves water and has improved drought tolerance under future climate conditions. New Phytologist 221, 371-384.
3. Dunn, J., Hunt, L., Afsharinafar, M., Meselmani, M. A., Mitchell, A., Howells, R., Wallington, E., Fleming, A. J. and Gray, J. E. (2019). Reduced stomatal density in bread wheat leads to increased water-use efficiency. Journal of Experimental Botany 70, 4737-4748.

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