The role of barley cell wall polysaccharides in host plant defence mechanisms against powdery mildew

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Abstract

- The cell wall is the first line of plant defence, presenting a barrier that protects cells from infectious pathogens in the surrounding environment. Plants respond dynamically to pathogen attack at the cell wall level by developing papillae at the infection site. In many plant/pathogen interactions, papillae formation is an important determinant of pre-invasion resistance by the host species. While many aspects of papillae are known, the cell wall components responsible for making papillae an effective barrier to fungal penetration are not fully understood. This project aimed to define the role of cell wall polysaccharides in the papillae-based penetration resistance mechanism of barley. Using the barley-powdery mildew host-pathogen system, papillae polysaccharide composition and the genetic factors responsible for their biosynthesis were examined.
- Here it is demonstrated that the major polysaccharides found in barley papillae are callose, arabinoxylan and cellulose. The papillae are layered with an inner core consisting of callose and arabinoxylan and an outer layer containing arabinoxylan and cellulose. A higher level of polysaccharide staining at non-penetrated papillae compared to the penetrated papillae was observed and this suggested that the polysaccharides are necessary components of the papillae-based penetration resistance mechanism of host plants.
- The members of the *Glucan synthase-like* (*Gsl*)gene family found in the barley genome have been characterised and identified and when *HvGsl6* was silenced this resulted in a loss of callose in the papillae and an increased rate of successful fungal penetration.
- A number of candidate genes from several glycosyltransferase families suspected to be associated with the biosynthesis of arabinoxylan in papillae have been identified. Transient down-regulation and up-regulation of the individual candidate genes using a biolistic DNA delivery system led to an altered level of susceptibility to powdery mildew. However, the highest levels of resistance were observed when GT43 (MLOC_54026) and the GT47

(MLOC_14407) genes were over-expressed together. These genes are putatively involved in arabinoxylan backbone biosynthesis.

- Furthermore, this PhD study also contributed to the characterisation of the role of the *HvCslD2* gene in non-host resistance, a project led by Dr. Patrick Schweizer, IPK, Germany. We showed that silencing of the *HvCslD2* gene in barley results in reduced cellulose accumulation in the papillae during powdery mildew infection, suggesting that *HvCslD2* is a key gene involved in cellulose biosynthesis in papillae.
- The association of high levels of arabinoxylan and cellulose deposition in papillae with the penetration resistance mechanism of the host plant, provides new targets for the improvement of papilla composition. The identification of the genes involved in the biosynthesis of each papilla component will provide new targets for the generation of novel crop lines with greater disease resistance.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Md Jamil Chowdhury Date: 30 March 2016

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LIST OF PUBLICATIONS

1. **Chowdhury J**, Henderson M, Schweizer P, Burton RA, Fincher GB, Little A. 2014. Differential accumulation of callose, arabinoxylan and cellulose in nonpenetrated versus penetrated papillae on leaves of barley infected with Blumeria graminis f. sp. hordei. *New Phytologist* 204(3): 650-660.

2. **Chowdhury J**, Schober M, Shirley NJ, Jacobs A, Douchkov D, Schweizer P,. Fincher GB, Burton RA, Little A. Down-regulation of the *Glucan synthase-like 6* gene (*HvGsl6*) in barley leads to decreased callose accumulation and increased susceptibility to Blumeria graminis f. sp. hordei. Submitted to New Phytologist journal. Submission ID: NPH-MS-2016-21945.

3. Douchkov D, Lück S, Hensel G, Jochen Kumlehn J, Rajaraman J, Johrde A, Aghnoum R, Rehman S, Kopischke M, Fuchs R, Lipka V, Niks R, **Chowdhury J**, Little A, Geoff Fincher G, Bacic T, and Schweizer P. The cellulose-synthase like *CslD2* gene mediates host- and nonhost resistance in barley. Accepted to publish in New Phytologist journal. Submission ID: NPH-MS-2016-21786.