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IMPACT OF AGRICULTURAL PRACTICES ON PLANT DISEASE: WHAT CAN WE LEARN FOR RESISTANCE INDUCERS OPTIMIZATION?

Elsa Ballini, Huichuan Huang and Jean-Benoit Morel

1 SupAgro, Agrosys, UMR BGPI INRA/CIRAD/SupAgro, Montpellier, France

2 College of Plant Protection, Yunnan Agriculture University, Kunming, Yunnan, China

3 INRA, UMR BGPI INRA/CIRAD/SupAgro, Montpellier, France

Contact: elsa.ballini@supagro.fr

Introduction

The Chair Agrosys “Engineering for sustainable agrosystems”, supported by Montpellier SupAgro, aims to bring together stakeholders in R&D (public and private), businesses, farmers around a platform to develop technical and scientific guidance. One of our goal is to better integrate biocontrol solutions in farming systems. For this purpose, we organized a workshop in May 2017 gathering all the actors of biocontrol experiment at the field level. Some participants focused particularly on resistance inducers. At this occasion, many scientific questions raised but one of the factor that has a strong impact on these products efficiency in the field is the agricultural practices. Indeed agricultural factors such as nitrogen fertilizers and drought are known to increase the level of many plant diseases. Here we will focus on one of our research project and the impact of nitrogen on the susceptibility of rice to the blast fungus *Magnaporthe oryzae*.

Material and methods

Standard fertilization solution was supplied every Monday for 3 weeks. Twenty-six days after sowing, we supplied on Monday either a fertilization solution containing a nitrogen source (1N condition), or the same solution without nitrogen source and corresponding to the 0N condition (Ballini et al., 2013). This fourth fertilization was done 1 day before inoculation. We also used a mock treatment corresponding to the solution into which spores are re-suspended (i.e., 0.5% gelatin solution). Five to seven days after inoculation, symptoms were analyzed using ImageJ software. Tissues sample were collected 2 days after fungal inoculation for dual RNA sequencing and were sent to BGI Tech (Huang et al. 2017). The RNA sequencing depth allowed a good coverage of rice and *M. oryzae* genes. Differential expression between all repetitions was performed for each of the four conditions 0N mock inoculated, 0N *M. oryzae* inoculated, 1N mock inoculated and 1N *M. oryzae* inoculated. *M. oryzae* differentially expressed genes were confirmed by quantitative PCR experiments.

Results and discussion

Agrosys chair organized a workshop in May 2017 gathering all the actors of biocontrol field experimentation. The participants have submitted to the research community four main family of questions on induce resistance. The first one is about the application, its quality, its timing and the new ways to reach the target. The second one is about pathogens, diversity of response to the products and durability of induce resistance challenged by evolving pathogen effectors. The third one was about varietal response to plant inducers and new breeding programs for a more efficient induce resistance. The last one was about the impact of the environment and in particular, the agricultural practices on these products efficiency in the field.

Here we will focus on one of our research project and the interaction between the blast fungus *Magnaporthe oryzae* and rice. Our objectives were to understand the mechanisms by which nitrogen is inducing blast susceptibility (NIS) and drought is inducing blast susceptibility (DIS) (Ballini et al., 2013; Bidsinski et al., 2016). In order to understand these mechanisms, we have conducted a dual RNAseq experiment on rice-infected tissues (Huang et al., 2017). At least four hypotheses can be proposed to explain Nitrogen-induced Susceptibility: an indirect effect via plant growth, an increase in nutrient availability for the fungus, a regulation of plant immunity by nutrients like amino acids and a direct, positive regulation of fungal pathogenicity functions by nutrient availability. Using the interaction between rice and the blast fungus *M. oryzae*, we provide some elements to these different hypotheses and propose a model for the possible molecular mechanisms triggering NIS.

Similarly, to previous results, our dataset clearly indicate that nitrogen fertilization increases susceptibility despite an increase in the expression of several defense genes. Therefore, there is no clear-cut indication that a weakened defense system could be responsible for the NIS phenomenon. This enhanced defense may be directly or indirectly due to an increase in some metabolites (e.g., Glutamine). On the other hand, the fungus perceived small differences after penetration and nitrogen fertilization seems to fuel pathogen growth. Moreover, we have highlighted that the pathogen modified the expression of effectors and pathogenicity related proteins. We propose that after nitrogen fertilization, despite an increase in defense, the host does not succeed in facing a concomitant increase in pathogenicity of the fungus, leading to enhanced susceptibility.

These results allow us to conclude that agricultural practices may affect defense inducers efficiency more likely indirectly through a modification of pathogen aggressivity rather than after a breakdown of the immune system.

Highlights

Understanding why nitrogen fertilization increase the impact of diseases may explain the lack of efficiency of resistance inducers. We propose that in plants supplied with elevated nitrogen fertilization, the observed enhanced induction of plant defense is over-passed by an increase in the expression of the fungal pathogenicity program, thus leading to enhanced susceptibility.

References

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