Breeding for disease resistance in barley: Challenges and opportunities when working on ramularia

Paul Bury – Secobra
Breeding for disease resistance in barley

Challenges and opportunities when working on Ramularia

Paul Bury – Barley Breeder, Secobra Recherches
• History of breeding efforts to address Ramularia resistance
• Some initial discoveries and viewpoints
• Challenges in breeding and improving control
• What now?
Recent history of breeding efforts to control Ramularia. Personal experience from a UK perspective

- Mid 1990’s in UK there was a rapid rise in spotting in Spring Barley
  - Mostly in North/Scotland
  - Cv’s Chariot/Landlord
  - Some variation noted between lines, but most were susceptible to varying degrees
- We became aware of similar concerns in Republic of Ireland, Germany, Austria, Norway and others
- Small informal group developed with the support of Mike Collins and New Farm Crops to share knowledge and experience and look for ways forward
  - David Cranstoun/Simon Oxley/Neil Havis – SRUC
  - Edelgard Sachs – Germany
  - Herbert Huss – Austria
  - Saideh Salamati – Norway
  - George Garland – Ireland
- ‘Blotch’ projects proposed and some funding followed
  - SPOTEX?
Early comments

“Ramularia is a silent assassin hiding in your cupboard. Before we realise, it will come out and kill us”  Herbert Huss 1990’s

“Has the ban on stubble burning and mercury seed treatment contributed to the increase in Ramularia?”

“What happens in plant physiology to cause symptom expression only later in the life cycle? Sink and Source effects within green leaves”
Some outcomes of early years of study

Agreement?
- Identification of Ramularia
- Little variation in resistance in commercial material
- Difficult phenotyping due to climate and other diseases

Fake news?
- Symptoms generally less near to Oak trees
- Ramularia is not a real disease
- Funcicides will control it OK
Some key learning from early work

• Lack of major resistance genes
  • Thousands of lines were screened in various projects across the world
  • No lines have been found that show full resistance to *Ramularia*
  • Any resistance is likely to polygenic with many genes having a small effect

• Strong environmental effects
  • Studies often conclude that over 50% of variation in symptom development is environmental rather than genetic

• Interaction with other diseases and physiological effects
  • Non Parasitic Leaf Spotting can be confused with and certainly interacts with *Ramularia* to reduce green leaf
  • The mlo mildew resistance genes are linked to higher infection levels of *Ramularia*
Slow progress in early years?

- Limited funding
- Maybe too much focus on fungicide control
- We were able to identify areas for further research and attention
  - Endophytic lifestyle of the fungus
  - Seed borne transmission
  - Role of Rubellins and light intensity
  - Need for reliable artificial inoculation methods
  - Interaction with other diseases
- But plenty of areas still to be developed
  - Full description of life cycle
  - Sexual stage still not known
  - Understanding the rapid recombination and evolution of the fungus
  - Lack of variation and sources of resistance
- Learnt a LOT about the background to the disease, made good contacts
CORACLE project 2009-2014

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Control of ramularia leaf spot in a changing climate

James K.M. Brown¹, Neil D. Havis², James M Fountaine²,*; Graham R.D. McGrann¹,#, Margaret M Corbett¹, Maciej Kaczmarek², Simon JP Oxley²,#, Marta Piotrowska², Joanne Russell³, William TB Thomas³

¹John Innes Centre, Norwich NR4 7UH; ²Scotland’s Rural College, Edinburgh EH9 3JG; ³James Hutton Institute, Dundee DD2 5DA. Present addresses: * Syngenta, # SRUC, # AHDB
Challenges when trying to work on Ramularia resistance breeding

- Difficult Phenotyping / Disease assessment
- Environmental variation. (incl seed infection levels)
- Limited inoculation techniques
- Lack of resistance sources
- Rapid recombination and evolution of Rcc
Difficult Phenotyping –
Many Barley leaf blotches have similar symptoms
Ramularia is VERY environmentally dependant

• Infection generally greatest when cool wet weather occurs around heading time
• Hot and Dry – No Symptoms
• Stressed / droughted crops – Less symptoms
• Late varieties show less symptoms than Early lines on a given day
• Levels of Rcc in seed are likely to influence symptom levels
Inoculation methods

• Quite a few successful inoculation techniques have been claimed

• Mostly seedling methods in protected environments

• Personal experiences have not convinced me that these were reliable and well correlated to ‘natural’ infection in field
Lack of good resistance sources and rapid evolution

- Various large studies have concluded that there is little variation in resistance / susceptibility between varieties
  - UK, Denmark, Germany, Norway, Uruguay
  - In all cases, symptom levels follow a continuous quantitative variation
- No studies have reported lines without symptoms
- Rcc recombines freely and evolves rapidly EG. Early 2000’s G143 point mutation against strobilurin efficacy spread across Europe in 2-3 years
So...... Are we in a hopeless situation ?
Opportunities for improving resistance to Ramularia

• Traditional resistance breeding
  • Difficult, but by selecting in high pressure areas and with disease increasing, there should be some natural and forced selection for better resistance

• Make use of recent technical advances
  • Genome of Rcc published by McGrann et al 2016
  • Gene editing or targeted mutation breeding could be an extreme option? (An mlo equivalent for Rcc?)
Combine traditional resistance breeding and modern genomics?

• “Given that RLS scores on different cultivars appear to have a continuous distribution, it is most likely that, mlo apart, resistance is polygenic, with many genes dispersed throughout the barley genome, each having a minor impact on disease.”

Ramularia collo-cygni—An Emerging Pathogen of Barley Crops


• Take Genome wide approach
• Pool Phenotype data from many sources
• Genotype the material
• Develop predictions for Rcc Susceptibility / Resistance
• Ramularia collo cygnii is a smart and aggressive disease
• We need to be equally smart to make progress in controlling it