Keys to successful sclerotinia stem rot management in oilseed *Brassicas*

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Background and Objectives: Current management options in Australia against *Sclerotinia sclerotiorum*, the cause of Sclerotinia Stem Rot (SSR) in oilseed *Brassicas*, mainly rely on cultural and chemical controls that are often unreliable and can be cost prohibitive. Development of reliable and relevant methods of field screening diverse germplasm has been critical in the identification of high-level field resistance across diverse crucifer species. Recent ability to effectively characterize physiological specialization in pathogen populations has provided the first opportunity to not only monitor pathotype distributions, but to identify resistances against predominant pathotypes and to combine these resistances into future cultivars.

Results and Conclusions: Within *Brassica* species and interspecific breeding population studies and in other host screening studies, genotypes pathotype-dependent and some pathotype-independent in resistance expression have been identified. Pathotype-independent resistances are particularly important sources of resistance to exploit in developing new cultivars with effective resistance to SSR across multiple pathotypes. In addition to identifying high level host resistance to SSR, breeding populations of similar levels of resistance but narrow variation in the resistance range have also been identified. Such populations not only consistently display the level of resistance expected but also reflect genetic diversity of resistance sources needed to successfully develop new more-resistant cultivars. Significant progress in identifying appropriate host resistances against prevailing pathotypes makes successful management based on host resistance possible for Australia and elsewhere. Identification of distinct host resistance mechanisms and demonstration of separate genetic control for adult stem vs adult leaf resistances, are crucial to deployment of an effective array of resistances to manage SSR.

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KEYNOTE THEME B

Integrated pest management of insect pests of rapeseed

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Insects just love rapeseed! Surveys in the UK have shown the importance of the crop to a wide variety of invertebrates; 152 individual species and a further 50 groups were collected from the crop and identified to genus or higher taxonomic rank. The most abundant insects on the crop, perhaps unsurprisingly, were brassica specialist pests, but the crop also supports a great diversity of beneficial insects including the brassica specialist parasitoids of rapeseed pests and generalist predators such as ladybirds, lacewings and hoverflies. The diversity and abundance of invertebrates associated with the crop implies that, even when conventionally managed, the crop plays an important role in supporting populations of butterflies and pollinators, natural enemies of crop pests, and in maintaining food resources for farmland birds throughout the arable rotation. This potential could be harnessed further via use of Integrated Pest Management (IPM) approaches which minimise insecticide use.

IPM is an effective and environmentally sensitive approach to pest management that relies on a combination practices (including the judicious use of pesticides). There are four usual steps in IPM programmes:

1. Set action threshold

2. Monitor pest density & assess risk

3. Prevention – cultural methods e.g. crop rotation, use of pest-resistant cultivars; semiochemical e.g. pheromone repellents; habitat diversification e.g. intercropping, trap cropping

4. Control – mechanical (e.g. trapping); botanical; biological; conservation biocontrol (i.e. the encouragement of naturally-occurring enemies of crop pests to provide pest-regulation services in the crop); synthetic insecticides as a last resort.

The EU Sustainable Use of Pesticides Directive 2009/128 decrees that growers in Europe should use IPM wherever possible. But what tools are available now and what might be our options in the future?

In my talk I will introduce the major insect pests of rapeseed, detailing their life cycle and behaviours. I will then discuss the four steps of IPM programmes giving details and examples of each, with focus on my work on pollen beetles *(Meligethes aeneus)*, cabbage seed weevils *(Ceutorynchus obstrictus)* and cabbage stem flea beetles *(Psylliodes chrysocephala)*. Action thresholds exist for most of the major insect pests of rapeseed but they vary widely between countries for the same pest. I ponder why this is and stress that, as action thresholds form the basis of IPM programmes, their determination should be well-grounded from good science. Effective monitoring and risk assessment tools are needed to facilitate working to action thresholds. Monitoring methods for most of the major pests of rapeseed are available but most of them are onerous and therefore less often used than they should be. I will describe some recent advances in monitoring and risk assessment for pollen beetle. Most preventative methods are at the development stages. I will present work on the application of understanding host-plant location processes to the development of pest tolerant cultivars, trap crops and repellents. Finally, I will detail the main natural enemies of rapeseed pests and describe work to augment current agri-environment schemes to deliver effective conservation biocontrol in the rapeseed crop.

I would like to dedicate this talk to Prof. Dr. Lloyd Dosdall (1952 - June 12, 2014).

Blackleg resistance in oilseed rape *(Brassica napus L.)* and strategies for developing protection against this disease

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Stem canker (blackleg) caused by the fungus *Leptosphaeria maculans* (Phoma lingam Tode) is a major disease of Brassica napus worldwide, causing serious losses on crops in Europe, Australia and North America. A common and effective way to control this disease is the use of resistant cultivars. Two types of resistance have been described (1; 2) and used: (i) qualitative resistance controlled by specific single genes, which is effective from the seedling stage onwards and (ii) quantitative resistance, which is a partial, polygenic resistance mediated by Quantitative Trait Loci (QTL) and effective at the adult plant stage. Qualitative resistance can be quickly overcome by changes in the pathogen populations. The use of quantitative resistance, alone or in combination with qualitative resistance, was shown to be an effective way to get varieties with more durable resistance (3; 4). Both the diversity of genes involved in qualitative resistance and the potential diversity in genomic regions involved in quantitative resistance have been investigated. At least fifteen specific resistance genes have been described, of which two have recently been cloned and shown to be allelic (5). Genomic regions involved in quantitative resistance have been identified through linkage or association mapping. These studies showed that the complexity of this trait, with many homoeologous genomic regions involved, was related to the large number of duplications present in the B. napus genome (6). Optimal strategies for control of blackleg disease should take advantage of this diversity and take into account knowledge about the pathogen dispersal and adaptation ability to optimize deployment of resistant varieties in space and time.

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CONGRESS KEYNOTE
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KEYNOTE THEME B

Strategies for control of extracellular pathogens of oilseed rape

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Background and Results: Pathogens of oilseed rape *(Brassica napus)* may be classified as biotrophic (intracellular; *Plasmodiophora brassicae*, clubroot; *Hyaloperonospora brassicae*, downy mildew; *Erysiphe cruciferarum*, powdery mildew), hemibiotrophic (extracellular; *Leptosphaeria* species, phoma stem canker (blackleg); *Pyrenopeziza brassicae*, light leaf spot; *Verticillium longisporum*, verticillium) or necrotrophic (*Alternaria brassicae*, leaf and pod spot; *Sclerotinia sclerotiorum*, stem rot). This review will focus on short-term, medium-term and long-term strategies in Europe for control of diseases caused by the extracellular (apoplastic) pathogens. Short-term strategies include use of foliar fungicide sprays for control of phoma stem canker and light leaf spot. There are problems with insensitivity to triazole fungicides in *P. brassicae* populations, *Leptosphaeria biglobosa* is less sensitive than *L. maculans* and many effective fungicides may be withdrawn as a result of EU legislation (Carter et al.,2014; Huang et al., 2011). Optimal control of both disease requires fungicide application in autumn, which can be guided by web-based forecasting schemes (http://www.rothamsted.ac.uk/phoma-leaf-spot-forecast; Stonard et al., 2011). Medium-term strategies include breeding for resistance against the causal pathogens of all three diseases (Boys et al., 2012; Brun et al., 2010; vetricillium ref). Such resistance breeding programmes can be accelerated by understanding the operation of resistance (R) genes against extracellular pathogens, postulated to involve Effector-Triggered Defence (ETD) mediated through receptor-like proteins (RLPs), by contrast with Effector-Triggered Immunity (ETI) that operates against the intracellular pathogens (Stotz et al., 2014). Such R genes may lose their effectiveness at elevated temperatures associated with global warming (Huang et al., 2006). As a long-term strategy, it is essential to assess potential impacts of climate change on the range and severity of epidemics of these diseases, to guide government and industry policy for climate change adaptation (Evans et al., 2008; Butterworth et al., 2010).

Conclusion: It is important to develop appropriate short-term, medium-term and long-term strategies to control oilseed rape diseases caused by extracellular pathogens.

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Verticillium ref

KEYNOTE THEME B

Impacts of neonicotinoid use in oilseed rape and their mitigation

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In Europe the neonicotinoids clothianidin, imidacloprid and thiamethoxam have been used as seed treatment for more than ten years, including coating of oilseed rape. These actives have a comparably low toxicity to humans and other organisms such as birds. However, the safety of their use for bees is intensively discussed due to a high intrinsic toxicity to honeybees and comparably long persistence. On the other side long persistence and systemicity provide good control of soil and leaf-feeding pests. Honeybee toxicity has become more relevant for environmental regulations since severe bee incidents occurred during sowing of maize in 2008 caused by abrasion of clothianidin from treated seeds and drift of dust to adjacent areas. More than 12000 bee hives were damaged in Germany; some drift incidents also occurred in other European countries, the US and Canada. The exposure via dust drift during sowing had been neglected within risk assessment. After 2008 further research on other routes of exposure such as residues in guttation droplets were initiated. Risks due to exposure via residues in pollen and nectar were already considered when products containing these actives were first authorized, though residue detection was less effective at that time.

In 2013 the EU Commission suspended the use of these neonicotinoids for at least 2 years for crops which may be attractive for honeybees. Our latest research indicates that residues in guttation droplets are sufficient to kill single water collecting bees in several crops including rape but no effects on colonies were observed. Under German environmental conditions guttation provides no unacceptable risk of neonicotinoids to bees. Research in 2014 did not show any effect of residues in pollen and nectar on honeybees, bumblebees and solitary bees; though low max. values (>6 µg clothianidin/kg) were detected in pollen and nectar of winter oilseed rape (10 g clothianidin / kg seeds). Higher residues might occur in summer oilseed rape depending on treatment rates. In response to bee incidences in 2008 and its link to maize sowing of neonicotinoid-treated seeds, dust abrasion of seeds as well as dust drift during sowing were investigated. Dust abrasion of oilseed rape seeds showed that seeds treated in 2008 produced distinctly less abrasion compared to seeds treated before with further improvements in the following years. Drift experiments during sowing indicated varying quantities of neonicotinoids in adjacent crops originating from seed treatment with varying seed dust qualities. No effects on bees were detected if Heubach abrasion values of oilseed rape seeds per hectare were around 10 mg a.i. or lower. But the a.i. was still detectable up to 30 m from sowing. In general, negative effects on bees only occur if bees visit plants adjacent to the sowing. Bee safety can only be guaranteed by low dust abrasion and low contents of a.i. in dust.

No bee poisoning incidents were attributed to neonicotinoid seed treatment in oilseed rape in Germany in more than 10 years of use although almost all oilseed rape was treated with neonicotinoids.

KEYNOTE THEME B

Strategies and challenges in the management of clubroot disease of canola

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Background: Clubroot is an important soilborne disease of crucifers caused by *Plasmodiophora brassicae*. It first emerged as an issue in the Canadian canola *(Brassica napus)* crop in 2003, when 12 clubroot-infested fields were identified in the province of Alberta. Annual surveys have since revealed that the disease is spreading at a fairly rapid rate, with nearly 1,900 confirmed infestations by 2014. The main mechanism of dispersal appears to be via the movement of *P. brassicae*-infested soil on farm and other equipment, although the movement of pathogen resting spores in windblown dust also has been documented (Strelkov & Hwang, 2014). Clubroot can cause significant yield and quality losses in susceptible crops, and the long-lived nature of the resting spores makes it difficult to control.

Management: Initially, clubroot management was focused on the sanitization of field equipment and long rotations out of canola in *P. brassicae*-infested fields, although neither strategy was widely implemented by farmers. The efficacy of various soil amendments and fungicides also was evaluated, but while some could significantly reduce clubroot severity, most were not cost effective for the large-scale canola production systems of western Canada (Hwang et al. 2014). Nonetheless, the fumigant metam sodium may have potential as a spot treatment to contain localized infection foci in areas where *P. brassicae* is still not established. Canola cultivars with excellent resistance to the predominant pathotypes of *P. brassicae* first became available in 2009-10 (Peng et al. 2014; Strelkov & Hwang 2014), and quickly came to be the most important clubroot management tool employed by farmers.

Challenges: *Plasmodiophora brassicae* continues to spread, with isolated infestations recently identified in the Canadian provinces of Saskatchewan and Manitoba, as well as in the neighboring American state of North Dakota (Chittem et al. 2014). As such, farmers in affected regions increasingly have relied on resistant canola cultivars, often growing them in very short rotations in heavily infested fields. This has placed tremendous selection pressure on pathogen populations, and in 2013 resistance was overcome in at least one field in Alberta. Further testing under greenhouse conditions showed that all canola varieties classified as clubroot resistant are susceptible to the strain of the pathogen from this field. Surveys in 2014 suggest that resistance has been overcome in several other fields, highlighting the continued vulnerability of the canola crop to *P. brassicae*.

Conclusions: Clubroot is a serious threat to canola. Genetic resistance to *P. brassicae* represents the most important management tool, but has been overcome in at least one field and likely others. This underscores the need for resistance stewardship and longer rotations out of canola where clubroot is an issue.

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