Stem canker of oilseed rape: molecular tools and mathematical modelling to deploy durable resistance

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ABSTRACT

SECURE (Stem canker of oilseed rape: molecular tools and mathematical modelling to deploy durable resistance; QLK5-2002-01813) aims to deliver a model for deployment of cultivars with resistance to *Leptosphaeria maculans* (phoma stem canker/blackleg) to improve durability of resistance and minimise risk that the resistance will break down. The objectives are: 1. To construct a model of the life cycle of *L. maculans* and validate it with existing data; 2. To compare the fitness of virulent/avirulent races of the pathogen and develop genomic analysis of avirulence and virulence loci; 3. To analyse effects of plant genetic background and environmental factors on durability of resistance, both in field and controlled conditions. 4. To model effects of resistance deployment strategies on durability of resistance and recommend a sustainable strategy. Results will be disseminated and discussed during the course of the project using a website, scientific and popular publications and workshops. The SECURE project is supported by the European Commission under the Fifth Framework Programme.

INTRODUCTION

Stem canker of crucifers is caused by a complex of ascomycotous fungi collectively named *Leptosphaeria maculans* (anamorph: *Phoma lingam*) and is a disease of major economic importance. Globally, the importance of the disease increased dramatically with the development of the oilseed rape crop as a major break crop in many parts of the world (West *et al*., 2001). The most severe epidemics have recently occurred in Australia and during the early 1970's, the disease was almost responsible for the demise of the developing oilseed rape industry (Bokor *et al*., 1975). In Europe, the breeding of *B. napus* cultivars displaying "field resistance" was successful in reducing the incidence of the disease until the end of the 1980s. However, in the 1990s, severe epidemics of stem canker have been observed in many EU countries (West *et al*., 2001). This suggests that severe epidemics of stem canker will be observed whenever agro-climatic conditions meet the requirements of the pathogen(s), and whenever the level of resistance are insufficient or inadequate.

L. maculans is now known to be a species complex consisting of at least two species, of which only one (*L. maculans sensu stricto*: A group or Tox^{+}) is associated with occurrence of severe basal stem canker epidemics. Resistance to *L. maculans* is generally considered to include major single-gene resistance expressed at the seedling stage and polygenic “field” resistance expressed after initial infection, which reduces growth of the pathogen in the plant. Polygenic resistance in Jet Neuf was widely used for 10–15 years, both as a cultivar and as a source of resistance in new cultivars. Although the resistance of Jet Neuf was considered polygenic, a major resistance gene (*Rlm4*) was also present (Balesdent *et al*., 2001). However, most of the cultivars with resistance against *L. maculans* have had race-specific resistance (Ansan-Melayah *et al*., 1998). As with major gene resistance in other agricultural crops, use of this type of resistance has been very effective at protecting crops in the short term, but the resistance has broken down rapidly. A good example is the use of resistance gene *Rlm1*, which provided good stem canker resistance in France during the early

1990's (Ansan-Melayah *et al*., 1997). However, heavy selection pressure due to the large area of *Rlm1*-containing oilseed rape cultivars grown caused this resistance to be overcome. During the period 1996-99, a large increase in the proportion of the pathogen population which carried the corresponding *avrLm1* allele (for virulence) was observed (Balesdent *et al*., 2003). Unfortunately, due to the narrow genetic base of *Brassica napus*, sources of resistance to *L*. *maculans* are rare. There is therefore a need to manage the use of available resistance very carefully to prolong the use and "durability" of the resistance genes.

THE "SECURE" PROJECT

The SECURE project (QLK5-2002-01813) aims to model factors affecting durability of resistance and produce strategies for sustainable management of durable resistance to stem canker caused by *Leptosphaeria maculans* on oilseed rape. The response of polygenic (Pilet *et al*., 1998) and monogenic (Chèvre *et al*., 1997) resistances alone and in combination will be compared. Detailed knowledge of the selection for virulence in *L. maculans* populations and the effectiveness of host resistance under different conditions will be crucial to achieving this aim. The work will use molecular and modelling techniques in addition to specialised controlled environment and field experimentation (Brun *et al.*, 2000) to study the adaptation of the fungus populations to the different types of resistance. *In vitro* morphological examination, pathogenicity/resistance tests and field disease assessments will be used to identify *L. maculans* and study interactions between *L. maculans* races and oilseed rape genotypes. The *L. maculans* population race structure will be evaluated using conventional assay methods and novel molecular methods. Controlled environment experiments will be used to study the mechanism of resistance to pathogen growth and the comparative fitness of virulent vs avirulent isolates. To investigate natural populations of *L. maculans* and produce a practical strategy for sustaining durable resistance against stem canker, field experiments will also be done across Europe. Data from the project will be used to answer questions raised by a recent paper, produced through SECURE, describing measures of durability and consequences in agricultural systems (van den Bosch and Gilligan, 2003).

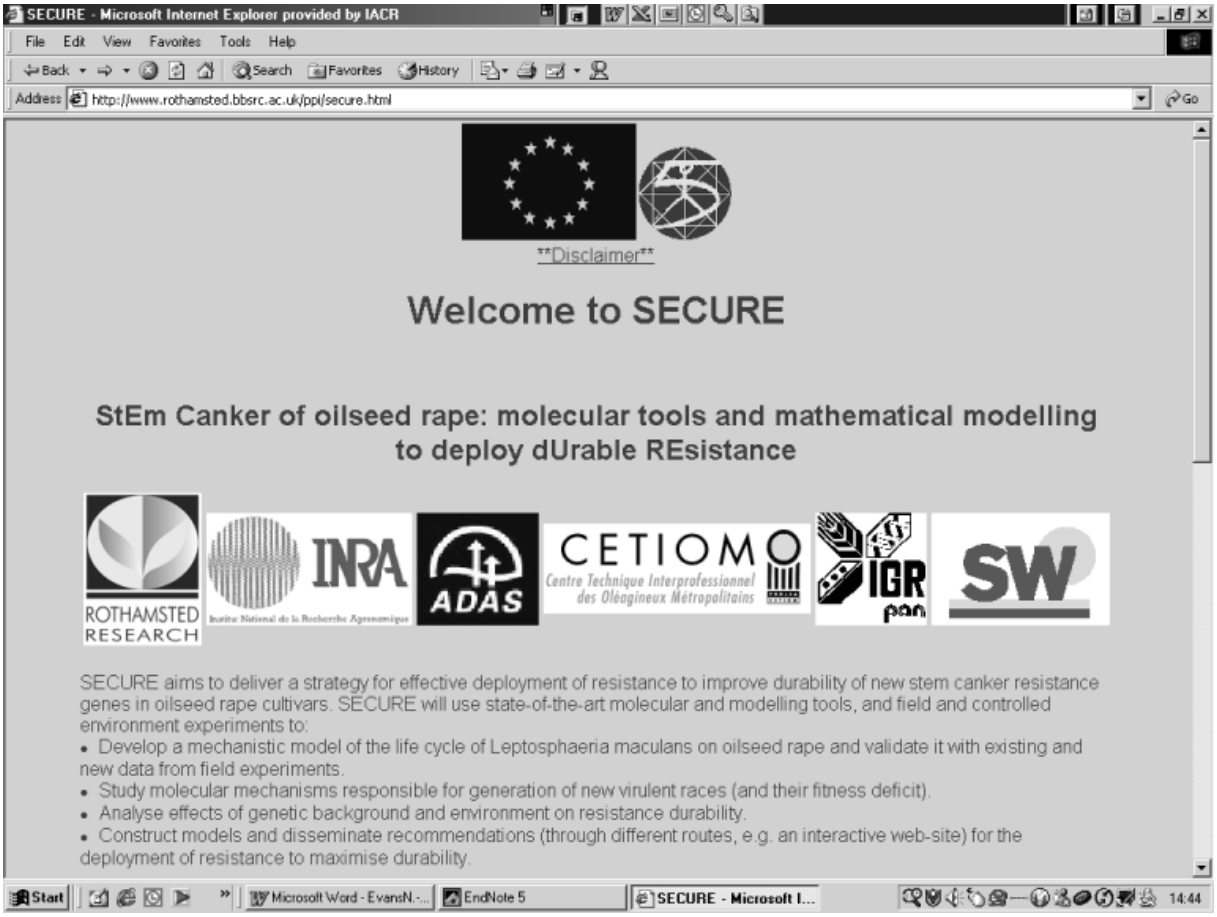

Fig. 1. Frontpage of the SECURE interactive website (www.rothamsted.bbsrc.ac.uk/ppi/secure.html) which details the main partners involved in the scientific work and the aims of the project.

"SECURE" OBJECTIVES

The four objectives and main work packages of the Secure project are:

1. To produce a mechanistic model of the life cycle of the *L. maculans* pathogen.
2. To investigate the effects of pathogen variation at Avr loci on durability of resistance.
3. To investigate the effects of genotype/environment on durability of resistance.
4. To develop a strategy for the sustainable deployment of durable resistance.

DISSEMINATION OF RESULTS AND RECOMMENDATIONS

A range of communication routes will be utilised to ensure that the four target groups (A. policy makers/politicians/government agencies; B. plant breeders/advisers/farmers; C. the international scientific community; D. Citizens groups and the general public) are made aware of project results in general and in particular the expected new developments in managing genetic resistance against stem canker in oilseed rape. The main dissemination route will be a dedicated, interactive project website (Fig 1):

www.rothamsted.bbsrc.ac.uk/ppi/secure.html

This will allow discourse between scientists working on the project, farmers/advisors, other scientists and members of the other target groups specified above via interactive bulletin boards and discussion groups. Traditional routes of dissemination (agricultural technical press, peer-reviewed scientific journals, topic sheets, participation at scientific conferences) will also be used during the project.

ACKNOWLEDGEMENTS

This project is supported by the European Commission under the Fifth Framework Programme (http://www.cordis.lu/life ; Contract no. QLK5-2002-01813). Work at Rothamsted Research is also supported by UK Defra and the BBSRC. Work at IGR is supported by Polish national grant KBN Project 3/P06A03422.

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