Correlation among life-history traits in plant-pathogen interaction and consequences for epidemic spread: a case study in the wheat leaf rust pathosystem

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Quantitative traits, referred to as aggressiveness components (from the pathogen side) or resistance components (from the host side) are usually measured in controlled conditions on individual plants, and at the scale of a single pathogen life cycle, whereas epidemic development is measured in the field and encompasses a succession of elementary life cycles of the pathogen.

Assessment of these traits is required to measure components of quantitative resistance in the host, to compare the fitness of pathogen strains, or to parameterize epidemic models. In these three cases, the question is raised of how each elementary quantitative trait contributes to the development of an epidemic, but very few information is available in the literature on this matter, and it is mostly based on theoretical studies. The objective of this study is to understand the contribution of elementary traits of pathogenicity to epidemic development in field conditions.

A set of wheat cultivars was confronted to three different leaf rust pathotypes, both under controlled and field conditions, during three consecutive years. In the greenhouse, Infection efficiency (*IE*), latent period (*LP*), lesion size (*LS*), spore production per lesion (*SPL*) and spore production capacity (*SPS*) were measured. In the field, disease severity (*DS*) was measured at three different dates.

Generalized Linear Models in a Bayesian framework were developed to estimate the quantitative traits and the field epidemic development variables for each cultivar-pathotype pair. Finally, i) the correlations between the estimated quantitative traits, and ii) the correlations between quantitative traits and epidemic development in the field, were investigated.

Most but not all the quantitative traits were related between them. Positive relationships (*IE-LP, IE-SPS, LP-SPS* and *LS-SPL*) can be interpreted as a pleiotropic effect of genes/QTLs influencing different resistance components of the host, or different aggressiveness components of the pathogen. Negative relationships (*LS-SPS, LS-LP, LS-IE* and *IE-SPL*) reflected trade-offs effects between components of host resistance, or between components of pathogen aggressiveness.

All the individual quantitative traits were correlated to the resistance in the field, except *SPL*. The strength of this relationship varied across the course of the epidemic, all traits being more strongly related with *DS* at the beginning of the epidemic. Later, the influence of *LP* and *IE* on *DS* decreased or get stabilised, whereas the influence of the sporulation traits on *DS* increased as the epidemic ended.

Traits covering all the pathogen life cycle have to be taken into account, whenever comparisons of the fitness of pathogen strains, or the resistance of plant cultivars under field conditions, are to be computed from the quantitative traits measured in controlled conditions.

Negative correlations between the traits represent a potential evolutionary constraint for the parasite. The knowledge of these relationships enables to identify combinations of resistance components prone to ensure an efficient and durable field resistance.