Eighth Workshop of an European Network for development of an
Integrated Control Strategy of potato late blight
Jersey, England/France, 31st of March – 4th of April 2004

Exploitation of cultivar resistance using reduced fungicide dose rates, the Wageningen UR approach

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Key words: *Phytophthora infestans*, decision support systems, potato late blight, fluazinam

Introduction

In 2004, the umbrella plan Phytophthora, a new initiative on potato late blight control in the Netherlands, was launched. Within the umbrella plan Phytophthora the Dutch grower organisation LTO, the potato industry, the potato trade and Wageningen UR co-operate to achieve the common goal of a 75 % reduction of the environmental burden due to late blight control within 10 years. Within Wageningen – UR, all *P. infestans* related research is co-ordinated and focussed on this goal. The Dutch Ministry of Agriculture, Nature and Food Quality is funding the Wageningen UR Research of the umbrella plan.
One of the aims of the umbrella plan is to better exploit the possibilities of (more) resistant cultivars within a potato late blight (PLB) control strategy to reduce the chemical input when possible. The objective of this paper is to outline the approach developed by Wageningen UR to be able to reliably reduce fungicide dose rates while maintaining adequate PLB control..

Concepts

Possibilities to better exploit cultivar resistance in potato late blight (PLB) control include application of fungicides in reduced dose rates and application of longer spray intervals. In both cases, growers rely on a reduced level of chemical protection (at least for some period of time) which must be "supplemented" by cultivar resistance to achieve the required level of protection.

PPO-Special Report no. 10 (2004), 211-214

Protective control strategy

Current PLB control strategies aim to protect potato crops against infection. For this purpose, protective fungicides are applied prior to periods conducive to *P. infestans* infection. When application of a protectant has been delayed due to e.g. bad weather, a curative fungicide can be employed up to approximately two days after the potential infection event. When this curative treatment cannot be applied, growers can wait and spray an eradicant in case of infection or resume with a protectant when infection has not taken place.

Disease pressure

Disease pressure is a rather loosely defined concept describing the infection risk as e.g. low, moderate or high. Estimates for disease pressure are based on an observer's opinion on local weather and influx of inoculum or they are derived from local historical weather data and a weather forecast. A quantitative estimate of the infection risk of a crop could help to refine control measures. Quantification of the actual infection risk to a crop would have to include estimates on the (predicted) influx of airborne inoculum, host resistance and (predicted) chemical protection level in combination with a local weather forecast. Influx of inoculum: Ideally, estimates for influx of inoculum should be based on accurate information on available sources and local weather so that source strength, release, survival of sporangia during atmospheric transport and deposition can be estimated. Information on local *P. infestans* sources will however never be complete. To avoid unnecessary risks to the crop, information on local sources could be replaced by the assumption that sources are available.

Cultivar resistance

For the purpose of this paper, cultivar resistance may be separated into vertical (absolute) resistance and horizontal (partial) resistance. In the absence of compatible *P. infestans*, vertical resistance provides absolute protection against infection and, at least theoretically, does not require extra chemical protection. Unfortunately, virulence against many or all R- genes or available R- gene combinations is present in most European *P. infestans* populations. In the presence of a (partially) virulent *P. infestans* population, R-gene containing cultivars can become infected when a compatible isolate "lands" in the crop. Thus, when the *P. infestans* population is partially compatible, presence of (an) R-gene(s) may bring about a delay in first infection.

Table 1. Components of resistance constituting the level of partial resistance of potato cultivars

Component of resistance	Symbol	Unit	Description
Infection Efficiency	IE	[-]	Fraction of successfully infecting spores
Latent Period	LP	[day]	Time span between infection and production of the first spore
Lesion Growth Rate	LGR	[mm day^{-1}]	Radial growth rate of a lesion
Sporulation Rate	SR	mm^{-2} day^{-1}]	Number of sporangia produced per mm^2 of leaf per day
Infectious Period	IP	[days]	Time span during which potato tissue remains infective

Partial resistance provides an intermediate level of resistance against PLB. Usually, four or five components of resistance are recognised that together constitute a cultivars partial resistance level. These components relate directly to the *P. infestans* infection cycle and are given in Table 1. Partially resistant cultivars are prone to infection but the higher the level of partial resistance, the slower the epidemic.

In practice, potato cultivars combine different levels of vertical resistance and partial resistance but for the purpose of a protective control strategy in the presence of compatible isolates the Infection Efficiency (IE) is the only component of resistance from which an infection risk can be derived.

Infection risk

Theoretically, the infection risk of a crop at any moment in time can be derived from the partial level of resistance (IE), the (remaining) level of chemical protection, the estimated influx of sporangia and the weather conditions in the near future (e.g. expected leaf wetness duration). During the growing season this estimated infection risk has to be kept below the maximum acceptable infection risk.

The maximum acceptable risk can be derived from e.g. the infection risk of a fully susceptible cultivar just before it has to be sprayed again with a protectant.

To be able to implement this strategy, a series of field experiments was carried out, reported upon elsewhere in this volume) in which IE was estimated for the 30 most important cultivars in the Netherlands. Additionally, in a second series of field experiments each of these cultivars was sprayed with 6 Shirlan dose rates (0%, 20%, 40%, 60%, 80% and 100% of the recommended dose rate) to derive the minimum dose rate required. Both the minimum dose rate required and the IE are used to derive the dose rate for a set of 5 cultivars, representing a range for IE, used in two validation field experiments under practical conditions.

The infection risk is influenced by cultivar, (expected) weather, atmospheric influx of sporangia, the remaining level of chemical protection and the dose rate applied. From these factors, the dose rate applied can be adapted to achieve the required protection level.