host ranges are excessively large, the soilborne pathogens *Sclerotium rolfsii* and *Macrophomina phaseolina* do not occur in temperate climates due to their high temperature optimum and frost sensitivity. Likewise, the distribution of *Verticillium dahliae* is limited because it is relatively intolerant to high temperatures. Comparative spread of pathogens and their hosts will be exemplified for rust fungi occurring in the Netherlands and reasons for the various distribution patterns, including climate change, will be discussed. Some other examples of dispersal of plant infecting fungi will be given.
Climate change can affect pathogen and pest dynamics in multiple ways. Crucial is the question whether the effect of climate change outnumbers other factors affecting the epidemiology of pests and pathogens, and if so, how pathosystem management should be modified. Although impossible to quantify, it is believed that in the majority of cases, potential invaders do not successfully settle. This success rate of introduced, potential invaders might be sensitive to climate change. For airborne pathogen and pest organisms, higher temperatures may lead to faster disease cycles, leading to an increase in disease spread, and to increased survival due to shortened and less severe frost periods. For soilborne pathogens, reduced frost may lead to increased survival of those species that do not tolerate frost. For soilborne pathogens that do tolerate frost, decreased exposure to frost could lead to germination during frost-free periods in the absence of hosts or, alternatively, triggered by the presence of weed hosts. As a result, new strategies to manage soilborne pathogens would be needed. Climate change will also invoke changes in farm management, which in turn may affect epidemiology of pests and pathogens. The already existing trend to advance planting crops to bring crops early in the season to the market is done because prices are then still high, but is done also to escape plant diseases. Such practices are currently carried out by organic growers to temporarily avoid potato late blight. This trend will continue when temperatures raise. The consequence will be that plant disease epidemics will start earlier, have a longer season, and, thus, polycyclic epidemics will show more disease cycles in one vegetation season.
Summarizing, it could be useful to separate various kinds of effects of climate change on plant pests and diseases leading to:

- changed probability of a pathogen to settle in a hitherto uncolonized area.
- changed epidemiologic characteristics such as duration of the life cycle and survival during the host-free season.
- changed farm management, such as a prolonged vegetation season.

The current fast changes in climate may lead to alike alterations in the epidemiology of pests and pathogens. To be able to better predict these changes, systems monitoring such alterations in an early stage could be of use.

Why is Dickeya spp. (syn. Erwinia chrysanthemi) taking over? – The ecology of a blackleg pathogen

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Potato blackleg caused by pectinolytic *Pectobacterium atrosepticum* (syn. *Erwinia carotovora* subsp. *atroseptica*), *P. carotovorum* subsp. *carotovororum* (syn. *E. carotovora* subsp. *carotovora*) and *Dickeya* spp. (syn. *E. chrysanthemi*) gives increasing damage in seed potato production in Europe. In the past, the blackleg pathogens contributed equally to the occurrence of blackleg, but in the last five years *Dickeya* spp. was responsible for 50-100% of the incidences in France and The Netherlands. In this paper, the diversity and some ecological aspects of *Dickeya spp.* are discussed, which may explain the increasing significance of this pathogen.

Dickeya spp. has been recently divided among six species, largely coinciding with seven biochemically distinct groups (biovars). In potato in Europe, before 2000 *D. dianthicola* (biovar 1 and 7) was almost exclusively found. This species is more adapted to temperate climates. Since 2000, a biovar 3 *Dickeya* spp. was isolated from potatoes grown in Israel, Finland, Poland and the Netherlands, which could not be classified in any of the six new species. Results from *dnaX* and 16S rDNA sequence analysis, rep-PCR and biochemical assays indicate that strains belonging to this biovar 3 variant are clonal. This variant has a higher temperature maximum than *D. dianthicola*. Possibly due to the increasing average temperature during the growing season,

the *Dickeya* biovar 3 variant is taking over from *D. dianthicola*.
In contrast to a biovar 7 *D. dianthicola* strain, the biovar 3 variant efficiently colonizes plant material. Soil infestation with a GFP-tagged strain resulted in a systemic colonization of potato plants within 30 days after inoculation. The biovar 3 variant was also able to colonize roots, stolons and progeny tubers from infected stems.

Spread within a crop may also occur during crop production if bacterial cells of *Dickeya* spp. are disseminated via free water in soil from rotten tubers to tubers of neighbouring plants. We showed that plants adjacent to blackleg diseased plants both within a row and between rows became contaminated after heavy irrigation. *Dickeya* spp. was able to cause disease symptoms even when present in seed at low densities. In field experiments with vacuum-inoculated tubers, a level of 40 cells per gram of potato peel was sufficient to end up with 30 and 15% diseased plants in 2005 and 2006, respectively. Such low levels of infection easily remain unnoticed during seed testing, even if sensitive detection methods are used. As for *Pectobacterium* spp., spread of contamination within and between seed stocks often occurs during harvesting and grading. In an experimental field, contamination with *Dickeya* spp. was spread by mechanical harvesting up to a distance of 80 m behind a zone with rotten tubers, with an average of 12 meter. Hand-harvested tubers from a disease-free crop remained clean.
Dickeya spp. seems to act like a biotrophic organism, which needs the host for long-term survival. *D. dianthicola* and the biovar 3 variant survived maximally for only three months in soil. Soil type, temperature and humidity only had a minor effect on survival.

In conclusion, a *Dickeya* spp. has become the dominant blackleg pathogen, probably due to its higher optimal growth temperature and its ability to colonize plant tissue more efficiently compared to *Pectobacterium* spp. The increasing importance of *Dickeya* spp. may be related to the increasing average temperature during the growth season due to global warming.

Impact of climate change on insect pests of trees

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In The Netherlands, insect pests on trees and shrubs are being monitored continuously since 1946. During these years, almost all insect pest populations showed marked changes, which may be the result of climate change, arrival of new pests, changes in forest management, shifts in forest composition etc.

In an earlier study, we analyzed the number of observations for all pest species in the database on deciduous trees. The results showed that since 1985, pest insects hibernating in the egg stage, numerically exceed insects hibernating as larva, pupa or adult. During the last 2-3 decades, the winters in The Netherlands have become relatively warm and more humid. In literature, it is stated that mild winter temperatures can reduce winter survival of adult, larval and pupal stages more than of the eggs, presumably because the first stages are more vulnerable for entomopathogenic nematodes and fungal activity. This phenomenon may be the cause of our observed increase of egg hibernators (Moraal *et al*. 2004).

In a later study, we have analyzed trends in 61 years of population development of the 91 most abundant species in our database, in such a way that frequently observed species did not bias the results. Of the observed species, only a minority occurred regularly over the entire observation period of 61 years. The remaining species showed population fluctuations that varied from single short-term outbreaks to long-lasting increases or decreases. On coniferous trees, most insect species showed decreasing numbers, while increasing numbers were found most on deciduous trees. In the increasing trend-group of Lepidoptera, more egg hibernating species were observed compared with the decreasing trend-group (Moraal & Jagers op Akkerhuis, in prep).

Future climate change models for our region, predict increasing temperatures, drought periods, and heat waves during the growing season. The European literature on pest outbreaks that followed after the exceptional drought of 2003, give us some indications of the impacts of extreme climatic conditions. Primary pest insects, mostly leaf-consuming larvae, are not dependant on the vitality status of the host trees. Secondary pests, mostly bark-boring species, are dependant on weakened trees e.g. by drought. In literature, some generalized predictions were made, based on current pest distributions and the severity of insect outbreaks in individual regions after the summer drought of 2003. The predictions are that tree mortality due to secon-