



# **Grower Summary**

**CP 184**

Cultural Control of Aerial Oomycetes  
Through Manipulation of the  
Protected Environment in  
Propagation and Protected Production

Final Report

**Project title:** Cultural Control of Aerial Oomycetes Through Manipulation of the Protected Environment in Propagation and Protected Production

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# AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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# GROWER SUMMARY

## Headline

There are a number of approaches for using cultural control of aerial oomycetes in protected production but more research to optimise their use in commercial systems is required.

## Background

Aerial oomycetes pathogens are responsible for a wide range of commercially important diseases in both protected and field horticultural production. They include the causal agents of downy mildews and some *Phytophthora* infections and can be rapidly spread via airborne spores.

A lack of available host resistance due to the emergence of novel pathogen isolates and restriction in the use of chemical control means that alternative approaches should be considered for the control of these diseases. As each stage of the aerial oomycete lifecycle is influenced by climatic conditions, so modification of the growing environment could be used to control diseases associated with these pathogens in protected production.

This review examines the environmental factors affecting aerial oomycete-associated diseases in protected cropping and summarise the cultural control studies made in relation to manipulating these conditions with regards to disease management. The review also discusses the importance of the effect of interactions between the environmental factors on pathogen biology and outline disease modelling studies which aim to aid outbreak prediction.

## Summary

The development of aerial oomycetes-associated diseases is strongly dependent upon a range of environmental conditions.

- **Humidity and leaf wetness** aid disease development.
  - Spore germination and infection normally requires free moisture, whilst spore production requires conditions of high relative humidity. If these conditions are not present, other environmental factors are considered to be irrelevant.
  - Overall, low humidity negatively impacts the survival of downy mildew pathogens. Attempts to reduce leaf wetness or RH (such as increased ventilation, air movement

such as fanning or increased plant spacing) could therefore be effective in the reduction of infection or sporulation, respectively.

- It is important to note, however, that a decrease in RH, if applied at the incorrect time of day, could actually trigger spore release from these pathogens.
- The **amount and duration of light** can affect developmental processes such as sporulation and infection in these pathogens.
  - Continuous broad- and narrow-band illumination has been shown to suppress the sporulation of many downy mildew pathogens. Continuous light application can prevent sporulation entirely in some cases, but could also decrease the latent phase of infection.
  - Night break lighting can prove effective against downy mildew diseases but is highly dependent upon the length of light and dark periods used, with the preceding dark period appearing to be of key importance.
  - Effects of white light do not pass to non-illuminated parts of the same leaf or plant. This could mean that parts of the crop which receive lower levels of illumination could prove to be problem areas. In addition, fruiting bodies may still be visible on leaves even if spores are not being produced.
  - For some pathogen species, red and blue light appear equally to be effective in control, in other species, only one of these two colours appears to be effective.
  - UV light, particularly in the UV-B (and perhaps also UV-C) ranges appear to have potential for control of these diseases, including as a 'priming' treatment, but careful optimisation of treatments is required to avoid crop damage.
  - Alternatively, polyethylene filters could be used to modify incoming daytime irradiance.
  - However, spore release can also be triggered by light e.g. in the morning as humidity decreases.
- The **temperature** of the growth environment can greatly influence the development of these diseases.
  - Temperature extremes negatively impact aerial oomycetes. Survival of downy mildew pathogens is generally considered to be negatively affected by temperatures above 35°C, but for some species of pathogen, survival can be reduced at lower temperatures.
  - Daytime solar heating, through the closing of ventilation or by covering the growth environment with polyethylene sheets to increase the temperature has been reported to be effective. The effectiveness of heat treatments appears to be dependent upon the stage of the infection.

- Many studies regarding the effect of high temperatures on downy mildew pathogens have been performed in countries with higher climatic temperature and sunlight levels than the UK, so the ability to achieve the required temperatures necessary for pathogen inhibition in the UK could be limited. One possibility could be to employ longer duration treatments at lower temperatures or to augment with supplementary heating provision.
- An important consideration for cultural control of aerial oomycete-associated diseases is the **strong degree of interaction between the different environmental factors** affecting their biology.
  - Such interactions must be considered when designing effective control strategies for these diseases, which may need to combine changes in more than one environmental variable simultaneously. Maintenance of suboptimal temperatures for pathogens in growing environments could potentially allow growers to reduce disease incidence where leaf wetness duration is difficult to modify, or vice versa.
  - It must be also noted that inoculum of downy mildew pathogens spreads better when temperatures are high and RH is comparatively low. This brings clear implications for using heat or humidity to control such diseases, as whilst disease processes such as germination or infection may be reduced, spores may spread more easily, highlighting a need to carefully optimise cultural control treatments and the timing of treatment application in order to obtain maximum efficacy.
- Aerial oomycete pathogens also appear to be **spread via contaminated seed**.
  - Some success has been reported using hot air and hot water treatments of seed.
  - However, as only a fraction of infected seed is required for an outbreak, this approach should be combined with other control methods. Similarly, screening of incoming seed batches is unlikely to be effective in eliminating disease.
- Limited research has been carried out regarding **early warning systems** for vegetable disease occurrence in glasshouses. The effectiveness of such systems will likely depend on how early they are able to predict likely downy mildew outbreaks. If infection has already occurred but symptoms are not yet apparent, i.e. the disease is in its latent phase, then effectiveness may be lower and the system could be more useful for assisting in the timing of fungicide applications rather than eliminating outbreaks altogether.

- **Other potential cultural control approaches** include:
  - An increase in plant spacing, avoiding overhead irrigation, rotations, rogueing, avoiding overwatering and hygiene strategies
  - Polyethylene mulches to cover the surface of growing media in order to reduce evaporation and humidity.
  - Treatment of irrigation water using e.g. hydrogen peroxide or UV.
  - Modification of the crop fertilisation regime.
  - Maintenance of good crop hygiene, the removal of infected plants, decontamination of the growth system and if possible, the use of rotations.

Control of humidity, leaf wetness, temperature and lighting offer a number of potential strategies for combatting aerial oomycete-associated diseases. It should be stressed that the interaction between these variables remains an important consideration in the design of cultural control methodologies. Despite the promising data produced, further research into optimising novel cultural control strategies tailored to commercial setups is likely to be required.

## **Financial Benefits**

Employment of cultural control versus aerial oomycete pathogens in protected horticulture may aid disease prediction and control. However, as the absolute efficacy of such control measures has yet to be fully established and will require tailored approaches for each pathogen and crop, precise predictions of financial benefits cannot be made at this stage.

## **Action Points**

The control of environmental variables in protected horticulture may offer a number of routes to assist in the control of aerial oomycete-associated diseases such as downy mildews. However, the interaction between these variables and their effect on such pathogens should be considered in the design of cultural control approaches. Pathogen biology is an important aspect and will impact upon the choice of timing and approach for treatment application. Finally, it should be stressed that some areas would benefit from further scientific investigation and optimisation for use in commercial setting and some will prove more cost-



effective and economically viable than others. The recommendations here will likely require careful manipulation to provide maximal possible efficacy against different diseases.

- Avoid overhead and excessive irrigation in order to minimise leaf wetness and RH.
- If possible, increase plant spacing to reduce humidity through increased airflow between plants. However, this may not be possible economically or due to space constraints.
- Consider increased natural or forced ventilation (potentially with the use of fanning if economically viable) to reduce RH and shorten LWD. Night time ventilation may be an option. Care should be taken to avoid the morning spore release period so that spore dispersal is not exacerbated. A reduction to around 60-90% RH may prove beneficial, depending on the disease.
- Alternatively, consider maintaining a slight positive air pressure using fans and/or air filters to reduce spore entry to the growth system.
- In some production systems, covering of the growth medium may be possible in order to reduce humidity from evaporation.
- Base or top pipe heating may aid RH reduction but may be prohibitively costly for some producers.
- Increase peak temperatures in the middle part of the day through closure of ventilation, supplementary heating and or film coverings as high temperatures are antagonist to many downy mildews. The temperature and duration required will vary depending on the pathogen and treatment achievable in the growth system. Again, care should be taken to avoid the morning spore release period so that spore dispersal is not exacerbated.
- Achieving low temperatures could be effective but this may delay and not eliminate disease.
- Consider heating the rootzone to e.g. 26-31°C for 2 weeks to combat these diseases.
- Whilst 24 h lighting is unlikely to be economically viable, the use of intermittent night break lighting using a broad (e.g. white) or narrow (e.g. red or blue LEDs) wavelength range may prove useful. Alternatively, polyethylene filters could be used to modify incoming daytime irradiance. The light intensity, timing and duration will likely depend upon the disease in question and unwanted morphological effects such as stretching and crop colour changes will need to be avoided.
- UV light, particularly in the UV-B (and perhaps also UV-C) ranges appear to have potential for control of these diseases, including as a 'priming' treatment, but careful optimisation of treatments is required to avoid crop damage.
- Treatment of irrigation water using e.g. hydrogen peroxide or UV.

- Monitoring of dew point leaf temperatures to aid prediction on conditions at risk of disease development.
- Modification of the crop fertilisation regime could prove beneficial but little data is available regarding this approach.
- Seed treatments using hot air or water should be considered for reducing disease incidence. However, as only a fraction of infected seed is required for an outbreak, this approach should be combined with other control methods. Similarly, screening of incoming seed batches is unlikely to be effective in eliminating disease.
- Finally, maintenance of good crop hygiene, the removal of infected plants, decontamination of the growth system and if possible, the use of rotations should also be carried out.
- It is important to remember that there is a strong interaction between the effects of light, humidity and temperature on aerial oomycetes – for example, the temperature optimum of the pathogen can change depending on the humidity and light level. However, this may mean that the use of temperatures which are non-optimal for the pathogen would permit longer LWD or higher RH with reduced disease and vice versa.
- These cultural control strategies may prove more effective when used in an integrated disease management strategy which combines them with chemical and host resistance where possible.

#### Areas for Further Work:

- Evaluation and optimisation of the potential for RH control of aerial oomycete-associated disease control in UK protected production systems through e.g. ventilation modulation.
- Further optimisation and evaluation of cost-efficiency of a range of lighting approaches for control of such diseases in commercial systems.
- Evaluation and optimisation of the potential for temperature control of aerial oomycete-associated disease control in UK protected production systems.
- The above work should also consider the strong interaction between the effects of light, humidity and temperature on aerial oomycetes and may need to investigate multiple factors simultaneously.
- Investigation of the potential for increased use of base watering in protected production.
- Determination of the potential for increased use of environmental monitoring for disease prediction and control.

- Investigation of disease control using modulation of fertilisation regimes.
- Evaluation of other potential cultural control approaches for aerial oomycete-associated diseases.