Horticultural Development Company

Grower summary

PC 278

The development and commercial demonstration of ducted air systems for glasshouse environmental control

Annual Report 2009

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

First year commercial trials of a ducted air greenhouse environmental control system have been successfully completed. Yields in the ducted air system greenhouse have been virtually identical to the control area but heating energy savings of 5% have been achieved. Disease levels have been significantly higher due largely to a range of early teething problems with the system.

Background and expected deliverables

This report summarises the findings of the first year of commercial trials of a three year project to investigate the performance of a ducted heating and ventilation system installed in a 1Ha tomato production greenhouse in the UK. The project follows on from PC 256 which examined the potential for using closed glasshouse technology in the UK. The main conclusion of this work was that the closed glasshouse concept could not be used in its entirety because of technical and financial constraints. However, the project identified that the application of one key feature of the design, the ducted air heating and ventilation system could offer significant advantages including:

- Reduced energy consumption.
- Improved crop yield.
- Reduced pest and disease problems.
- Increased opportunities to use alternative heat sources.

Objectives

The aims of the project are to:

- Reduce energy use in heated glasshouses.
- Reduce CO_2 emissions associated with glasshouse production.
- Expand the opportunities for glasshouse businesses to use alternative heat sources.
- Improve crop yield and quality.
- Reduce disease incidence and therefore the use of crop protection chemicals.

Summary of the project and main conclusions to date

Materials and methods

The project comprises three parts:

1. Research, development and design of a commercially acceptable ducted air heating and ventilation system for the trial greenhouse at a commercial nursery in the UK.
2. Installation of the selected system at the trials site.
3. Commercial trials to investigate system performance and crop response.

The project is being carried out at tomato growers Mill Nursery Ltd in East Yorkshire. A previous report (PC 278 Interim report, September 2008) covers items 1 and 2. This report details the first year of commercial trials carried out in 2008.

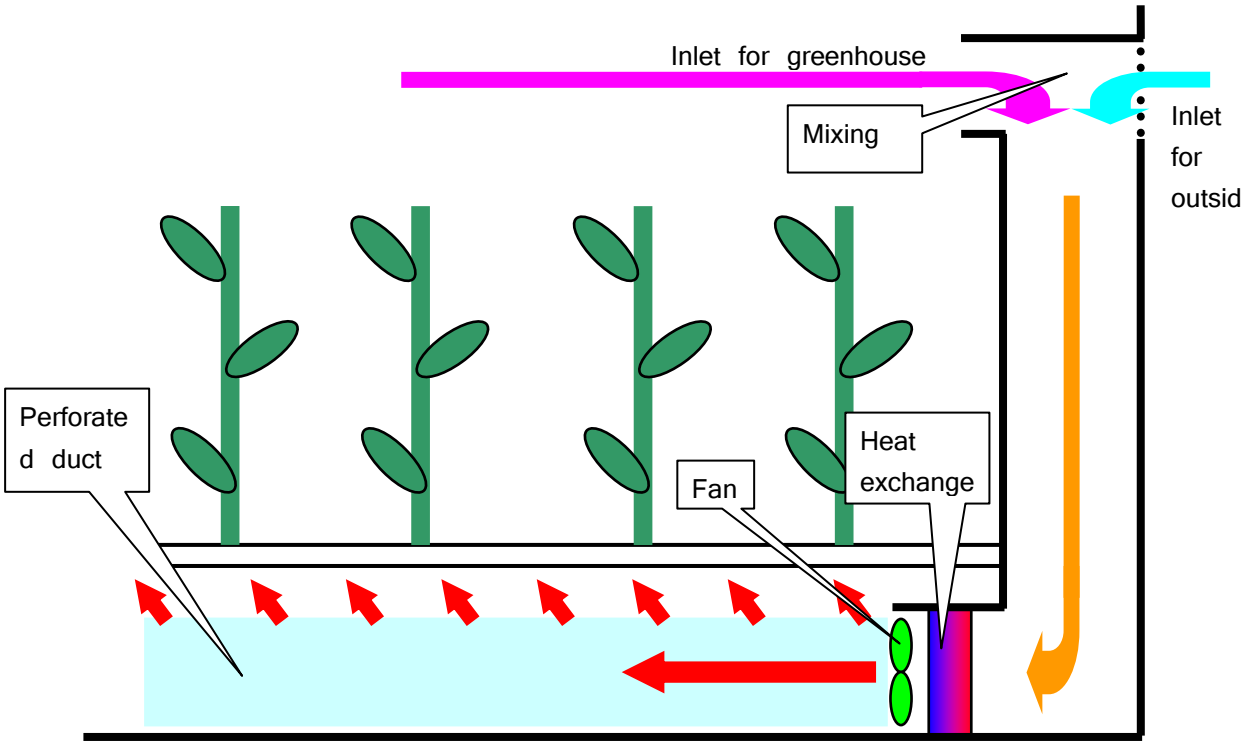
Trial site and equipment

Site

The project is being carried out in two adjacent 1Ha greenhouse compartments. A fan and duct system was installed in one compartment and is being compared with an adjacent and otherwise identical compartment which has a conventional heating and ventilation system.

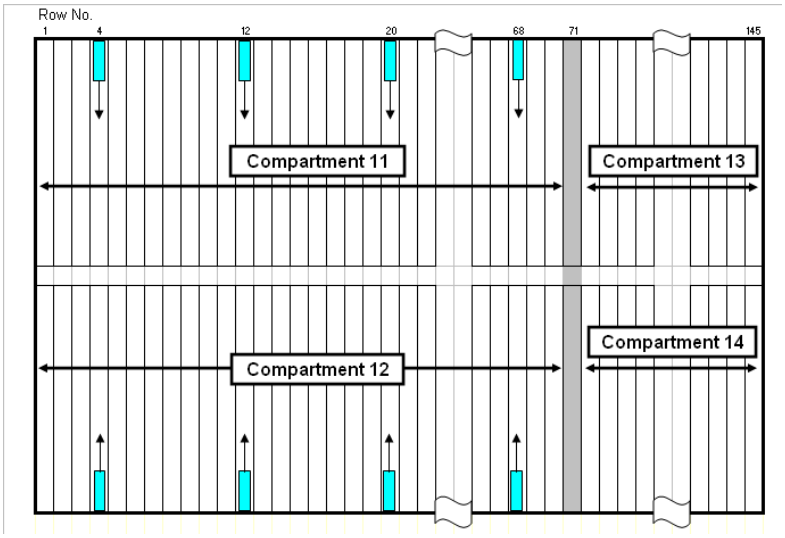
Equipment
Figure 1 below is a schematic showing a single air handling unit of the type installed at Mill Nursery.

Figure 1 – Air handling unit schematic



Collectively these components are called an Air Handling Unit (AHU). Each of the AHUs installed can deliver 6,000m^3/hr of air and have a heat delivery capability of 25kW. The installation at Mill Nursery used 18 of these AHU's arranged as shown in Figure 2 below.

Figure 2 – AHU layout



The fan and duct installation as a whole has a heating capacity of 450kW/Ha and delivers an airflow of 108,000m^3/hr (2 air changes per hour). It should be noted that the fan and duct installation is not capable of satisfying all the heating and ventilation needs of the greenhouse and the existing pipe rail heating system and roof vents continue to be used.

Results

As this report covers the first year of three years of commercial trials in which such a radical change in greenhouse heating and ventilation technology is being investigated, few firm conclusions or findings have been reached regarding crop yield, disease levels and energy performance.

System characteristics

Specific areas investigated included:

- Airflow and heat distribution along the ducting
- Uniformity of temperature and CO_2 within the greenhouse
- Speed of response – from zero to maximum heat output

Figures 3 to 5 below show the airspeed at the outlets along the duct, the air temperature at maximum heat output and the heat distribution all with the fans running at full speed.

Figure 3 – Outlet airspeed along a duct

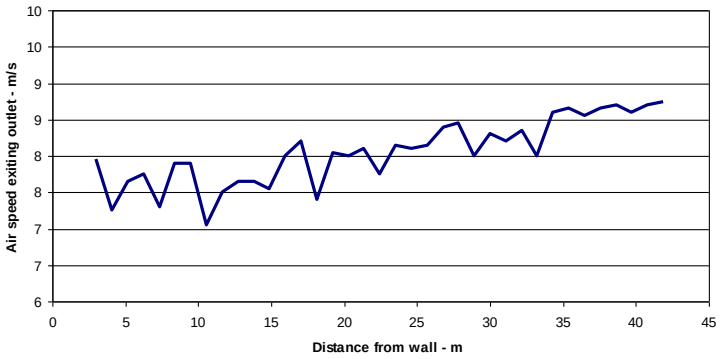


Figure 4 – Outlet air temperature along a duct

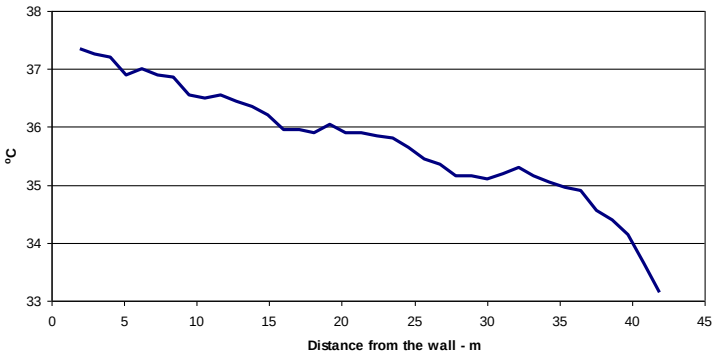
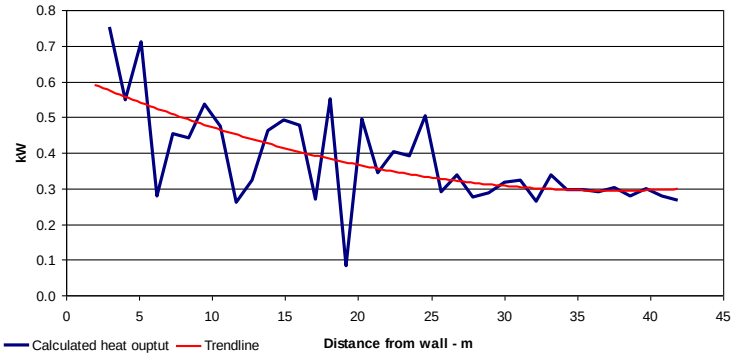


Figure 5 – Heat energy output along a duct



The significantly higher heat output close to the end wall of the greenhouse (next to the fan) is appropriate as heat losses are higher in this area compared to the middle of the greenhouse (next to the path). In spite of this temperature uniformity measurements carried out in late September 2008 showed that there was tendency for the compartment with fans and ducts to be colder at the wall. However, the difference between the coldest and hottest point was small at only 0.6°C. In the conventional compartment the wall was slightly warmer, however the difference between the coldest and hottest point was also 0.6°C.

Better air movement was expected to improve the uniformity of greenhouse temperature. Further work is required especially during the winter when the heat demand is high and differences in temperature are likely to be exaggerated.

An assessment of CO_2 uniformity showed that this was considerably worse in the fan and duct compartment. However, problems with the host nursery's CO_2 enrichment system meant that it was only possible to take a single set of measurements. As replicates of these measurements are not available their significance must be treated with caution.

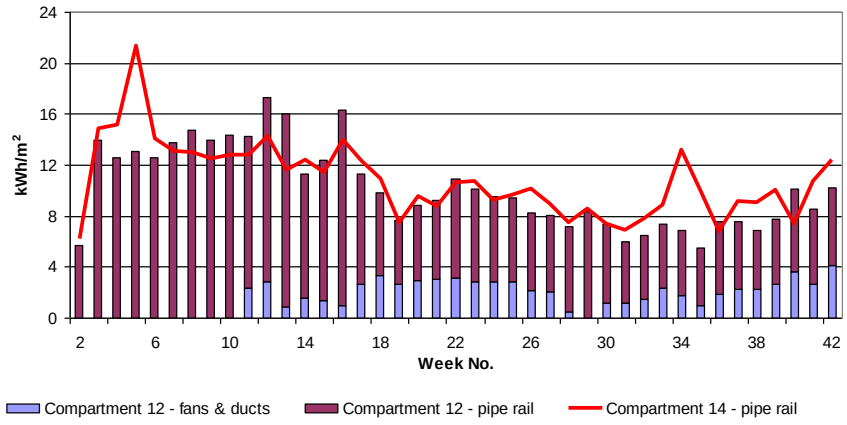
Speed of response tests showed that the fan and duct system could go from zero to maximum heat output at the farthest point of the greenhouse within 6 minutes. This is compared to 17.5 minutes for the pipe rail heating system. A high speed of response can be regarded as a benefit as it avoids having to hold residual heat in the system as 'insurance' – a common requirement with pipe rail systems.

Energy and crop data

Energy

The fan and duct installation was commissioned in week 11. The differences between the energy use in compartments 12 and 14 up to this point was due to a number of unrelated site problems. In week 5 there was a problem with the thermal screen in compartment 14 and it did not close. From week 7 to 11 there were also problems delivering sufficient heat to compartment 14. From week 30 onwards when many of the initial teething problems had been resolved energy savings of around 15% per week were achieved.

Figure 6 shows the weekly energy use in compartments 12 and 14.



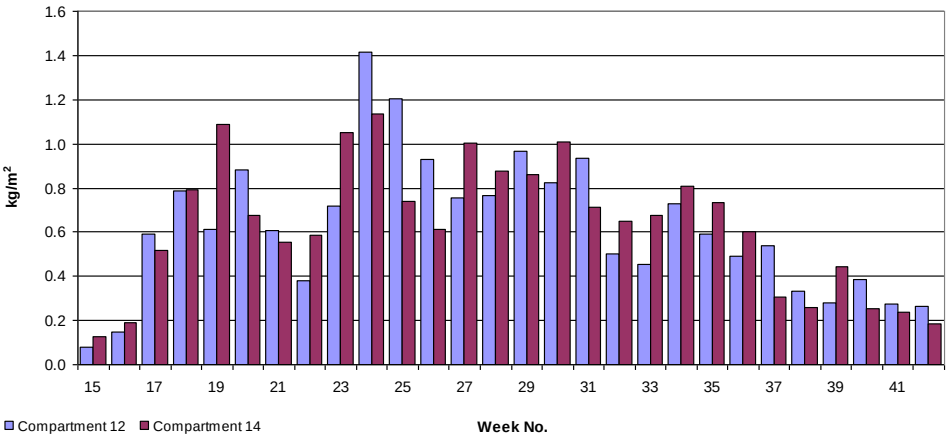
Over the whole year the total amount of heat used (as gas) in the fans and ducts compartment was 419kWh/m^2, compared with 443kWh/m^2 in the conventional compartment i.e. 24kWh/m^2 less (5%). However, the fans used 11.2kWh/m^2 which in terms of cost more

than offset the saving in gas. The cost of running the fans is recognised as an important factor and as experience is gained with the system they will be turned off whenever conditions in the greenhouse allow.

Crop

The variety grown in 2008 was Piccolo. Figure 7 below shows the weekly yield from each greenhouse compartment. Up to week 23 the fan and duct compartment tended to yield less. However, this was recovered in the following weeks and the total yield for the year was only 1% less. Bearing in mind the teething problems encountered this was considered to be a good result. The lower yield early in the season was thought to be due to slower ripening of fruit and this will be monitored more closely in 2009.

Figure 7 – Weekly yield



Disease assessments carried out by Dr Tim O'Neill (ADAS UK Ltd) showed significantly higher levels of botrytis in the fan and duct compartment. Although disappointing, it was not cause for concern at this stage in the project as teething problems meant that there were prolonged periods when the fan and duct installation severely compromised the growing environment.

The greenhouse environment and climate control strategy

Temperature and humidity conditions were measured using conventional wet and dry bulb measuring boxes located at the head of the crop and 50cm above the hanging gutter. The only difference of any significance was that the humidity deficit in the fan and duct compartment was consistently lower. This was expected as humidity control set points were relaxed in this compartment in anticipation of reduced disease risk from improved air movement.

The target greenhouse temperatures were set according to the needs of the crop and not with the aim of achieving identical conditions. Having said this, plant development was similar in both compartments and therefore the set points were in fact the same throughout 2008.

It was possible to control the fan and duct installation independently of the existing pipe rail heating and greenhouse ventilators. For heating, the strategy employed throughout 2008 was to use the pipe rail heating to provide a low background level of heat whilst using the fan and duct installation to 'top up' as required. If the capacity of the fan and duct system

was not sufficient, the pipe rail heating was then allowed to make up the difference. A similar approach was applied for both humidity control and cooling.

Achieving satisfactory control of the greenhouse climate with the fan and duct system proved to be a challenge throughout 2008. This was due in part to the complexity of the control system and other unforeseen conditions. One significant fault was that the control system allowed unheated outside air to be blown in through the ducts and this is believed to have caused condensation in the lower part of the crop. This last point has since been rectified by the addition of a minimum duct air temperature set point.

Financial benefits

At such an early stage in the project it is not possible to draw any conclusions regarding the financial viability of ducted air systems for glasshouse environmental control. However, the fact that there was no yield penalty at this early stage in the project suggests that where a low cost waste heat source is available, the economics of fan and duct based heating systems may be favourable.

Conclusions and action points

Many factors have to be considered when designing and operating a fan and duct greenhouse environmental control system. It is much more complex than a traditional pipe rail heating system. At this stage in the project there are no simple recommendations that are both widely applicable to UK growers and that can be readily adopted.

This project continues into 2010 and growers are advised to await further results which will be publicised via normal HDC communication channels.