Grower Summary

PC 301

Targeting of humidity control, through the use of stem temperature measurements, to reduce stem botrytis and save energy in tomato production.

Final Report 2011

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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.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

Tomato stem temperature sensors can be used to fine tune glasshouse humidity control, helping to cut energy costs and prevent condensation/stem Botrytis development.

Background

Suppression and control of high humidity in glasshouses is important as it helps to prevent condensation on plants which may lead to fungal disease. It also promotes crop transpiration and growth. However, humidity control comes at a price and estimates suggest that heat energy used in the process accounts for 30% of the total required to grow crops such as tomato. Therefore, any improvement in the management of humidity control and related diseases has the potential to deliver significant energy savings and/or yield/quality benefits.

Currently, the main tool used to control humidity and predict condensation events is based around the sensing of general air humidity. However, air-humidity sensing is a rather 'blunt' instrument when it comes to avoiding condensation as it fails to consider the dew point and the 'micro' environment at the plant/air interface. It also fails to recognise the spatial differences in conditions both in the horizontal and vertical planes. Consequently, humidity control set points used commercially are lower e.g. under 85–90 % than would be necessary to prevent general condensation - and more heating energy is used than is strictly necessary. In addition, there are times when air-humidity sensing fails to predict condensation and disease occurs.

Sensing plant temperature and dew point at the plant/air interface itself, rather than relying on air-humidity sensing, can allow closer and more accurate control to be exercised, cutting heating energy costs and reducing disease risk.

One main problem to the adoption of this practice is the necessary adaption of sensing equipment to effectively measure plant surface temperature and the interpretation of the output by the climate control computer. Challenges include the selection of the right sensing technology (infra-red or contact sensors), accuracy, sensor attachment methods, assessing the speed of response of sensing systems and selecting the best place for sensing and number of points necessary for good control.

This project was commissioned to explore and evaluate these issues and recommend some better commercial solutions.

Summary

Stem temperature sensing can be carried out using either a contact or infra-red (IR) sensor type. Contact systems are likely to prove to be the best option in most cases as they are sufficiently accurate, relatively cheap, and less affected by external influences when compared with IR types.

Experiments showed that new patch-type contact sensors, which cost about £15 per sensor, provided acceptable accuracy and speed of response. An heat conducting compound, applied between the sensor and the stem, improved responsiveness of sensors although this is not expected to give measureable benefits in this application. The use of Velcro straps to secure sensors led to a small reduction in response speed, but this was within acceptable limits for the application. Bead type sensors were less accurate and slower to respond. Thermistor and platinum resistance type sensors were tested and were found to be equally good. The decision on which one to use depends on how easily they can be connected to an individual site's climate computer.

Infra-red sensing is more expensive and is instant in response. However, its accuracy and use was adversely affected by heat given off by sensor heads and the need to keep sensors trained on the plant stem.

Stem temperature can be measured at different levels the see Figure below:

The trial looked at measurement at the top of the crop, at the de-leafing level and at the bottom of the crop. Top positions could be heavily influenced by solar radiation and at least weekly repositioning would be required. Top sensors were also prone to disturbance during plant work. The de-leaf level was similarly affected although the influence of solar radiation was a little less. The bottom of the crop measurement was easier to manage because of lower solar influence and less disturbance. There were only marginal differences between the de-leaf height and the bottom sensor temperature results, so it is recommended that only bottom sensing is necessary in practice for condensation control. Although top sensors are more challenging from a practical point of view, they offer further insight into temperature in relation to crop development.

The micro-environment at the plant stem was shown to vary across the crop. Therefore, it is recommended that if stem temperature is to be monitored, then it should be taken at four positions in the row; with sensors positioned suitably well away from the walls and central passage.

Integration of sensors into climate control system computers is not straightforward, as sensors may not be accepted as plug-and-play items. However, they can be integrated into a simple DC amplifier to produce a 0–5 V signal which can be interpreted by the climate control computer.

Financial Benefits

Financial benefits and returns from using stem temperature monitoring as a method of controlling glasshouse humidity is not simple to evaluate, as specific benefits will be dependent on the ability of the grower to interpret and act on the results available.

The capital cost of systems is likely to be relatively low, with sensors being quite cheap. With money also being required for wiring and integration of the information into the glasshouse control system, and possibly receiving the necessary training to enable information from the system to be interpreted correctly and acted upon, a cost of £3,000 per hectare is realistic.

Potential benefits in terms of energy savings are significant, especially in terms of the necessary investment required to implement this type of control. With humidity control related heating costs averaging say £15,000 - £45,000 per hectare per annum, a conservative 3 % saving in this per year would give a simple payback on investment of three years. Added to this would be savings from avoidance of plant disease — which would depend very much on the current performance of the site before modifications.

Action Points

Stem temperature monitoring and associated humidity control are clearly a significant step forward compared with reliance on control driven by general air humidity sensing. This project identifies that the hardware required can be acquired at reasonable costs and can be adapted to work satisfactorily if care is taken with positioning, attachment and interpretation of outputs.

For growers who consider themselves to have a good technical grasp of the conventional components of humidity control and how their climate controller interprets sensor input, then adoption of stem temperature monitoring and humidity control would be a good step forward. It will allow them to employ a degree of control and access to information which would not be available from simple air humidity monitoring. For those who may be less sure about some of the finer points of humidity control, adoption of stem temperature based systems might prove to be challenging.

In either case, growers should consider an exploratory approach to this technology by partial adoption and initial monitoring before any move to integrate the outputs into the glasshouse environmental control system.

The following steps might be considered for those who are interested in exploring the opportunities for stem temperature based monitoring/humidity control.

- Select an easily monitored compartment or area where an installation might be suitable.
- Investigate the practical issues of installing sensors to a crop row with sensors at four positions down the row, plus an extra measuring box positioned a low level.
- Measuring temperature at the bottom of the crop is most important. De-leafing level sensing gives little more information than the bottom sensor and top sensing is of greatest interest from a crop development point of view.
- Talk to your control system supplier/technician about what needs to be done to enable the interface of sensors to the climate control computer.
- Choose a good quality and thermally light, patch type platinum resistance or thermistor sensor, as it will give the best accuracy. Paying a few pounds more for accuracy will be worth it.
- Position sensors on the northeast side of the stem to minimize radiant heating effects from the sun.
- Set up the climate computer graphs to compare measured stem temperature with dew point temperature.
- Note the times and conditions when stem temperatures get near or go below dew point temperatures and make adjustments as necessary. Similarly note when condensation events are observed in the crop and check the data of the graphs.
- After you know and understand the interaction between stem temperature, dew point and the operation of heating and ventilation, you might consider using the stem measurements to influence how the heating and ventilation work.