Humidification in potato stores

Background

Potatoes have a high moisture content and, in storage, attempt to reach an equilibrium condition with the environment around them. This process is limited by the potato skin but, in time, potatoes held at 5°C will reach an equilibrium relative humidity (RH) of 98% with the air around them[§].

When ventilating a potato store, air can potentially dehydrate the crop. As air moves through the potatoes it picks up heat which also lowers its relative humidity. This means the air can carry more moisture which is taken up from the air around the potatoes during ventilation. By supplementing the moisture content of the air through **humidification**, there is scope to increase its RH and reduce moisture loss from the crop as described above.

A further benefit of humidifying is **evaporative cooling**. If moisture is evaporated during the ventilation process, this has the effect of cooling the air at the same time. This means systems using humidified air can operate at tighter air/crop differentials as the differential is widened as a result of water evaporation. This is known as **adiabatic cooling**.

However, there are also some potential pitfalls to humidification. The first of these is an **increased risk of condensation**. Condensation occurs when air exceeds its maximum moisture carrying capacity (dew point). If air is humidified, its RH is raised, bringing the air closer to saturation (100% RH). It follows therefore that, at a given temperature, the margin between the air's condition and dew point is reduced. And, if temperatures are uneven, condensation will occur more readily.

Measurement of humidity is another problem area if this is to be used to actively control humidification. Cell humidifiers do not require active control but other systems do. Traditionally, RH has been measured using *wet and dry bulb thermometers*. The wet bulb is covered by a wick from which water is evaporated into an aspirated air stream; the difference between the wet and dry bulb temperatures can be related to moisture content of the air. Using such a system in a potato store is not a realistic option; keeping the wick clean is a laborious process. Dew point meters are an alternative but are prohibitively expensive and impractical.
The alternative is to use an *electronic* sensor. However, many of these are unreliable, especially when used at an RH in excess of 90% and often cannot react quickly enough to prevent saturation being reached.

Due to these problems, it is best, where moisture is being actively added to ventilating air, to do so by

a) adding moisture on an intermittent basis (e.g. through pulsing) and/or
b) have ducting below the level of the floor so that any moisture falling out in the duct system can be safely drained from the store.

[§] Potato Council Store Managers' Guide, p12.

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Systems

The humidification systems available divide into three primary types:

1. Cell humidifiers

These are systems that use a special perforated, treated paper membrane (cell) down which water is cascaded to humidify air that is blown through the membrane at right angles to the water flow. The cell has a very high surface area to optimise the uptake of moisture by the air drawn through the humidifier.

Cells are often fitted retrospectively to stores and therefore, because of their size, are mounted in the roof space of the building for operation as an independent unit. However, more cell humidifier systems are now being built into fan houses as a purpose-built feature of new stores.

Similar mechanisms are also employed in water based-coolers, such as those used for storage of leafy vegetables, although in these instances the water is chilled to maintain a low temperature, high humidity environment within the store.

2. Atomiser systems

Ultrasonic atomisers use compressed air to shatter the water into a very fine mist. Delivery of the water to the air is through nozzle(s), which are usually placed within the ventilation duct of the store. This allows the system to be relatively easily fitted retrospectively but there is a small attendant risk of free water being carried into the crop which requires close monitoring at all times.

3. Spinning discs

This method of humidification uses a high speed rotary atomiser to break the water supplied to the disc into a fine mist which then enters the store through the ventilation system. The technology is similar to that used in ultra-low volume spraying systems.

Again, it is suited to retrospective fitting, but does introduce a risk of some free water carry-over into the crop.

Atomiser

Cell humidifier

Use in Great Britain

The use of humidification in GB has been limited. There is little data on which to assess the extent of its use but, anecdotally, it has been confined to only a very few stores, often run by enthusiast operators.

But there has been more interest in the use of humidification in recent years, especially in processing stores (6-13°C), to reduce moisture loss from the tuber.

Other potential advantages claimed include:

- Reduction in pressure bruising/compression damage at the base of a bulk pile
- Removal of fungal spores on humidification screens/cells
- Improved turgor and tuber integrity

There is little data to support some of these claims. However, a series of trials was conducted several years ago at Sutton Bridge Experimental Unit[§] and the data from these experiments are summarised in Table 1.

Table 1: Data from humidification trials at Sutton Bridge

Year	Yr1		Yr2		Yr3		Yr4[1]	
Humidification	+ hum	– hum	+ hum	– hum	+ hum	– hum	+ hum	– hum
Airflow $m^3/s/t$	0.005	0.02	0.005	0.02	0.005	0.02	0.02	0.02
Fan run time %[2]	46.1	23.6	29.8	15.1	16.7	9.1	19.3	9.3
Weight loss %	4.4	6.5	5.1[a]	5.6[b]	5.0[a]	8.7[b]	4.6	4.4
Compression damage %	1.9[a]	23.6[b]	28.1[a]	35.8[b]	16.3	13.0	36.6[a]	46.4[b]

[1]All trials conducted in 15 tonne experimental bins except Year 4 when 500 t bulk stores were used
[2]as proportion of total storage period except for Year 1 data which is proportion of total ventilation time

More recently, trials were conducted at Sutton Bridge in 2006 on the effects of cell humidifiers on pathogen inoculum levels in store air. A humidity cell was able to trap 99% of fungal spores that had been sprayed directly into the airflow of the humidity cell (Fig 1). In trials using 12-tonne experimental controlled environment stores at SBEU where dust or spores had been introduced, stores with cell[*] and ultrasonic nozzle humidification systems installed had similar levels of fungal spores present in the air throughout 11 and 17-day experiments. Dust and spores disappeared from store air within a few hours of being introduced into the plenum air recirculation duct. It is the opinion of the authors that the store infrastructure (fan coil, plenum surface etc.) attracts and traps spores, either through electrostatic or hydrostatic attraction. Natural inoculum in store dust also disappeared within hours of being introduced, probably because the relatively large particles settle out of air quickly. However, bacterial contamination was higher in sampled store air when humidified using an atomised system than with an evaporative humidification screen. It is likely that the atomised water was itself the source of contamination.

Case studies were also conducted in 2006 on cell and ultrasonic installations on commercial farms. Data from this work is presented in Figures 2 and 3.

Health & safety

The use of humidification can involve a range of issues for which health & safety risk assessments may be required. These include the use of compressed air and atomisation of water into aerosols which under specific temperature conditions could impact upon human health.

Please ensure that you are fully aware of any implications and seek specialist advice if you are unsure on any aspect of health & safety in relation to an installation. More information can be obtained on the Health & Safety Executive website at www.hse.gov.uk

Recommendations

- Consider the use of humidification only where you already have a well-sealed building with a close level of temperature control (range <0.5°C).
- Don't expect humidification to rectify major deficiencies caused by incorrect ventilation systems or poorly specified refrigeration.

§ Artificial humidification under low and standard rates of forced draught ventilation. Sutton Bridge Annual Reviews, 1982-6.

* *Munters HM2 4000*, Munters Ltd, Huntingdon, PE29 6EE, UK.

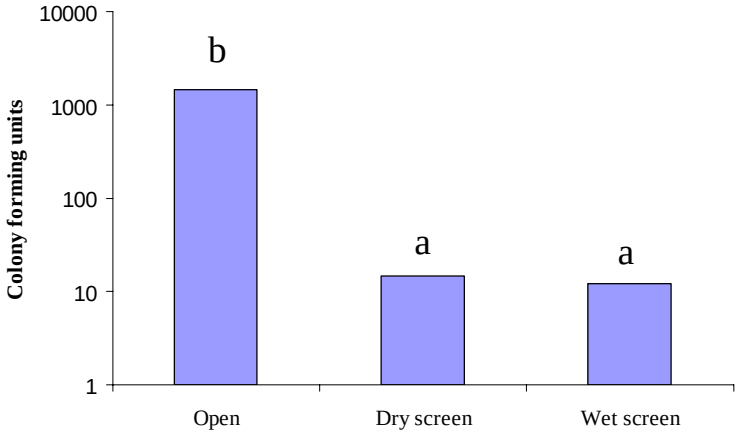

Figure 1. Colony forming units of *Fusarium sulphureum* recovered from the humidifier unit outlet with screen removed (open); screen installed dry; and screen installed wet (i.e. normal operation). $LSD_{(P=0.05)}$= 911 (14 df). Different letters above the columns indicate a significant difference at $P<0.05$.

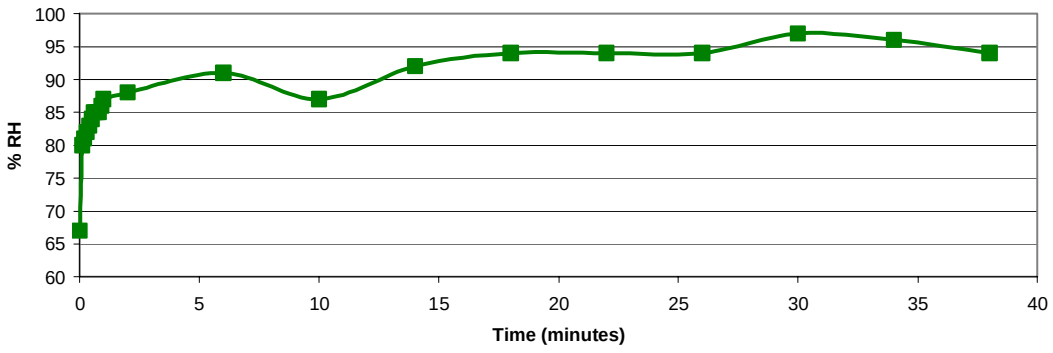

Figure 2. Case study 1: Bulk store ventilation using inverter-controlled fan and cell humidification

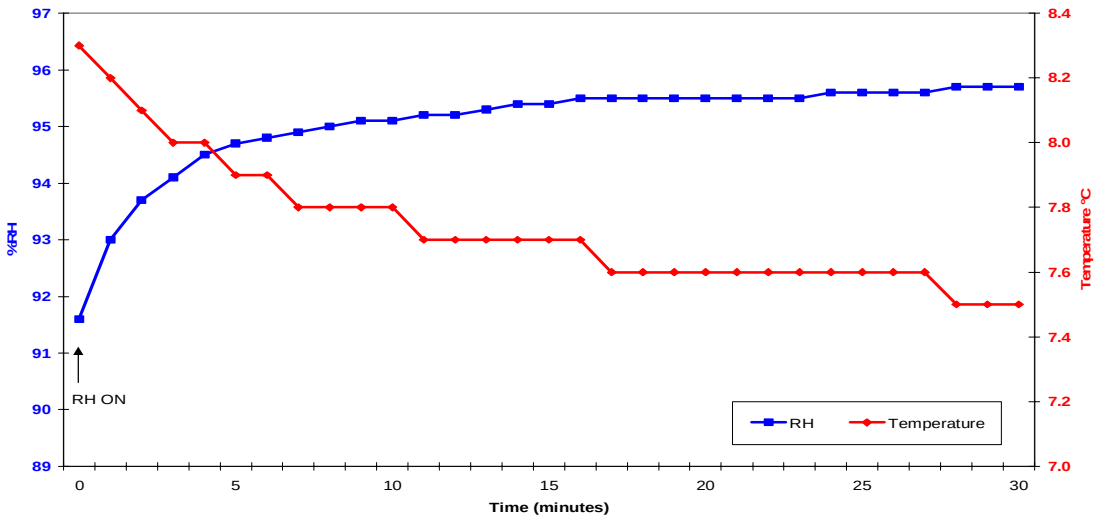

Figure 3. Case study 2: Bulk store ventilation with ultrasonic humidification illustrating cooling effect