

ROTHAMSTED RESEARCH CEREAL TRANSFORMATION TISSUE CULTURE ROOMS SPECIFICATION

1.0 REQUIREMENTS

- 1.1 The research conducted at Rothamsted research requires accurate and reproducible controlled environments for culturing young plants in tissue culture. A variety of plants will be grown in tissue culture, predominantly cereals but will include brassicas, willow, potato and camellina.

For the proposed research, accurate control of light intensity, day length, temperature, relative humidity and airflow is needed. In addition, the environment must be free of excessive concentrations (above normal atmospheric) of undesirable gases such as ethylene, ozone, sulphur dioxide, and carbon monoxide as well as any trace phytotoxic vapours.

For purposes of definition, the words "Tissue Culture Room" will mean the total system, and the words "growing area" will mean the area within the tissue culture room where plants are grown. "Growth height" is the maximum distance between the light barrier or lamp bank and the shelf on which the plants sit.

Two rooms are required for culturing plants through tissue culture. A key consideration will be a demonstrable system of reducing or elimination of condensation in the tissue culture flasks/containers/plates.

Energy consumption and lifetime costs are important to Rothamsted Research. An estimated energy usage (Kwhr) is required for 4 situations:

- All rooms running at lowest temperatures, 15°C, all lights on mid-summer day (35°C ambient 50% RH).
- All rooms at highest temperature, 30°C, all lights off mid-winter night (-10°C ambient).
- All rooms at highest temperatures, 30°C, all lights on mid-summer day (35°C ambient 50% RH),
- All rooms running at lowest temperature 15°C all lights off mid-winter night (-10°C ambient).

Lifetime costs at 5 to 10 years to include maintenance and any replacement consumable (filters etc) costs:

- at 5 years
- at 10 years.

The supplier should supply details and addresses of at least three tissue culture room installations, with at least one of a similar design, with permission to approach the present room users.

2.0 PHYSICAL CONSTRUCTION

2.1 Materials

Because the growth room is subjected to high humidities and a wide temperature range, it must be constructed of rustproof materials such as aluminium, stainless or coated steel, or plastic and all finishes must be non-phytotoxic. All materials must be demonstrably non-phytotoxic.

2.2 Size

Due to constraints in the design of the building, room exterior dimensions in total for two rooms will be 5 metres by 3.5 metres and a 2.75 metre working height. The space is on the west side of the building and space is available outside for the refrigeration system. Each room will be 2.5 metres wide by 3.5 metres maximum. Nine square metres of growing space is required in each room, spread over 3 shelves on each side of a gangway. A fourth shelf and closer spacing of the shelves would be accepted if the condensation control could be shown to be effective. Additional usable growing space would be preferred if possible. Any proposed layout by supplier to be agreed with Rothamsted.

2.3 Interior and Exterior Finish

The interior walls should be matt white providing uniform light reflectivity. Walls should be smooth with a minimal number of crevices or joints. Walls will be impervious to gases or water. The walls should be of such a nature that surfaces are easily cleaned and will last at least twenty years without discolouring, corroding or losing reflective ability. The exterior finish should be cleanable, easily maintained and not subject to corrosion, fading or discolouring after twenty years. Supplier will provide a list of materials suitable for cleaning the walls as well as a recommended cleaning schedule.

2.4 Insulation

The rooms will be well insulated with a high overall thermal resistance. The manufacturer will supply details of the thermal resistance of the whole room. Materials will be non-phytotoxic and resistant to decay or chemical breakdown, especially from water.

2.5 Floors

The growth room will have a floor that will have no drain. Because the floor will be exposed to water, nutrient solutions (>pH 5), growing media and plant matter, it must be made of material that will not rust, corrode, or otherwise deteriorate under normal horticultural use. The floor should be easy to clean with no cracks or crevices and lipped up at the sides to at least 5 cm. (except at the door).

2.6 Doors and Seals

A lockable access door is required central to the outside working room. Effectively on one side of each room, doors effectively adjacent to each other. A minimum access of 900mm wide and a height of 1800mm is required. To allow for observation of the plants in the working area without exposing them to the ambient atmosphere, the inner access door must have a window of at least 100mm x 100mm in size that can be made light tight with a hinged cover. Door seals must provide a good seal. The supplier will supply details of how to replace the seals, with the appropriate source of the seals and current purchase costs. Door seals must be non-phytotoxic.

Doors must be lockable but not from inside (i.e. if locked from outside, an individual inside can still get out)

2.7 Shelving

Rooms should be fitted with shelving on each side of a central gangway spread over 3 shelves on each side. Shelves should be well insulated, fitted with an air gap to reduce heat transfer from lights. There should be a gap of at least 28 cm from shelf top to underside of lights. The bottom shelf must be at least 40 cm from the floor. The top shelf must not be more than 150cm from the floor. A fourth shelf and closer spacing of the shelves would be accepted if the condensation control could be shown to be effective. Additional usable growing space would be preferred if possible.

2.8 Other Access Areas

A minimum of one access hole must be provided to the room from the laboratory for water, instrument leads and gas supplies if required. The holes must be at least 5 cm. in diameter, or equivalent area. The holes must be capable of being completely sealed against gas and light transfer. Location of the access ports to be agreed with supplier.

2.9 Growth Room Sealing

The growth room needs to be sealed to prevent the transfer of insects in or out of the room.

2.10 Services

One double electrical socket at the far end of the central gangway of the tissue culture room at 150cm from the floor is required, waterproof to IP 65. Humidification will use Reverse Osmosis or similar treated water (10-35 micro siemens). Costs of humidification in terms of parts required during a 5-year period and a maintenance schedule must be provided.

2.11 Filtration.

Filters for the inlet and outlet fresh air should be accessible from within the room. Filtration to exclude 200 micron particles and insects or bigger should be fitted. Filters must be insect proof. Air flows and air exchange should make allowance for this.

3.0 **ENVIRONMENTAL CONTROL**

Temperature, humidity, airflow, and light must be controlled well enough to maintain the environment required for the research.

3.1 Temperature

The required tissue culture room temperature range is 15°C to 30°C with no lights and 15°C to 30°C with all lights on. The maximum differential, as measured at the point of control should be less than +/- 1.0°C as measured with a shielded aspirated temperature sensor. The supplier will provide details of the accuracy and characteristics of the sensor used.

A uniformity requirement of +/- 1.0°C with respect to the control temperature, with or without the lamps on, across the room on the middle shelf of the room. This will be measured with a shielded aspirated temperature sensor at 4 points in the room, two on each shelf a third of the way down the shelf from each end.

A maximum vertical temperature gradient of +/-1.0°C at a single point in time with respect to the control temperature on each shelf at shelf level is required with the lights on and off, as measured at three points in the centre of three shelves on one side. The same uniformity requirement is required vertically and horizontally. Temperature gradients will be measured with a shielded, aspirated temperature sensor.

The supplier will provide documentation to support the temperature uniformity requirements for the temperature range 15°C to 30°C with lights on and off (where applicable) at intervals of 5°C.

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At a change in temperature from day to night to day, the above temperature uniformity must be achieved within thirty minutes. Separate day and night temperature control is required. The ability to ramp temperature at beginning and end of day is required.

The location of the chiller plant must be on the west side of the building.

3.2 Humidity

Humidity control to maintain relative humidity in the range 55 to 70% +/- 5% is required. A uniformity of +/- 5% humidity, subject to ambient, is required at the point of control when humidification control is required. A NAMAS certified sensor is required and a recommended recalibration schedule should be provided. The sensor should be easily accessible for recalibration but not requiring recalibration or maintenance at less than 3-month intervals. Documentation must be provided to support the humidity range specified. The humidity sensor should be in the same location as the temperature sensor.

Humidity stability must be achieved within 30 minutes of any control change, subject to ambient, assuming no more than a 5°C temperature change or 10% change in humidity.

Separate day and night control, including ramping is required.

3.3 Light

A light level of 200 μmol is required at shelf level with a uniformity of +/- 10% over 80% of the shelf area. Lights must be dimmable, separately on each shelf, but still achieving uniformity as specified from 20 to 100% of full output. The preferred lighting option is Colour 84 fluorescent tubes. However Rothamsted will consider alternative options where energy savings could be made.

Suppliers should specify options including spectra, energy saving and cost of different lighting types (if offered).

3.4 Airflow

The airflow in the room of between 0.3 and 0.6 m s^{-1} is required to ensure good temperature uniformity. The airflow will vary no more than 10% from the average over a horizontal plane or vertical plane as measured in the centre of the growing area. Documentation verifying this, with details of the sensor used must be provided.

The growth room will also be equipped with an inlet to add fresh air from a ducted inlet if required. The ducted air will be pre-filtered, with an insect mesh capable of excluding thrips. However the room will require a 100 micron filter, which is insect proof, on the inlet air accessible from inside the room. The quantity of fresh air required will be adjustable from zero to four air changes per hour. The fresh air will enter at a point where it will thoroughly mix with the conditioned air before being introduced to the growing area.

Any air temperature and humidity measurements for the growth room should be on the basis of two air changes an hour, with an incoming ambient of 20°C and 70% humidity.

Air extracted from the room should pass through a 100 micron filter which is insect proof. The filter should be accessible from within the room.

4.0 **CONTROLS, MONITORING AND RECORDING**

Reliability of the control system is of utmost importance and it must be of high quality and proven design. At least three examples of control systems in use must be provided by the supplier with addresses and permission to approach the user.

4.1 A diurnal cycle (day-night) for temperature, humidity, and lighting, with each environmental variable independently settable is required.

4.2 The controller(s) used will be capable of standalone operation independent of any external overseeing computer control and monitoring system. Any setpoints will be settable from the growth room. Visible displays of current temperature, humidity and set points where applicable for these to be available on the front of the room.

4.3 The system must be capable of resuming operation automatically on restoration of mains power after a break. Due to high switching loads etc. within the building the controllers must be capable of withstanding anomalous power spikes etc. The controllers on each room should have the capability of being programmed from a host computer to permit programming and operation from a central location. However, each room controller(s) should have the necessary memory capacity to maintain control of the room if the host computer is not operating.

4.4 The controllers should have a proven reliability record.

- 4.5 The supplier will provide details of the accuracy of the systems used and the cost of spare controllers.
- 4.6 Full documentation and user training of software will be provided. The cost of a spare controller should be priced separately. The cost of training should be priced separately.
- 4.7 Each room will require an energy monitor.
- 4.8 All software must be capable of interfacing over the Rothamsted Intranet with various Rothamsted users. Data from sensors must be logged at a user defined interval and saved to an Excel compatible file for analysis by the user.

5.0 ALARM SYSTEMS AND OTHER EQUIPMENT

The growth room control panel should have a visual and audible alarm that is triggered by the high and/or low limit control(s) if their temperature, humidity or lighting settings are violated. A set of "volt free" contacts is required for connection to a remote alarm system, energised by an electrical system separate from that of the tissue culture room(s).

- 5.1 **Other Equipment**
The controls, relays, or solid-state components, such as circuit boards and circuit breakers, must be easily accessible for service.
- 5.2 An emergency alarm is required to actuate a visible and audible trapped alarm outside the room (above door). A volt free contact to link into the Rothamsted alarm system is also required.

6.0 OPERATING CONDITIONS

The growth rooms will be housed in a building where the temperature will be 5 to 40°C. Humidities would be in the usual UK ranges.

7.0 INSTALLATION

Installation will be by the growth room manufacturer. An agreed plan for services and base layout will be provided. A timetable of works, including commissioning will be agreed prior to work commencing. Installation should be completed by June 2018.

- 7.1 All instructions and manuals including 4 copies of each will be provided to cover the operation of the room. A list of spares that should be held at Rothamsted with costs must be supplied. The supplier will provide a cost for training a Rothamsted service engineer and one other on the supplier's equipment. A cost for maintenance over a five-year period assuming a 48-hour call out is required.

8.0 REFRIGERATION SYSTEM

A refrigeration supply for the rooms either individual units or for all the rooms is required. A Chilled water system is preferred but consideration will be given to alternatives. The refrigerant used must have a GWP of 2000 or less.

9.0 STANDARD OF PERFORMANCE AND ACCEPTANCE OF EQUIPMENT

The specifications as laid out above will constitute the performance specifications to be met. Acceptance will only be made when testing performed by the supplier has been accepted by Rothamsted staff, which will be within a month of completion of installation by the supplier. If the performance specification has not been met, the appropriate modifications or repairs will be made by the supplier and any tests required accepted by Rothamsted staff.

10.0 TESTS DURING ACCEPTANCE PERIOD

When the equipment is installed the tests required to gain acceptance (i.e. temperature control (lights on and off) at the low, midpoint, and high end of the specified range and the minimum, midpoint and maximum relative humidity control at the three temperature test points) will be made. While this testing is underway, light intensity, light uniformity, airflow and airflow uniformity tests will be made.

11.0 WARRANTY

The warranty period and requirements should be clearly specified.

An indication of the support availability, expected time for an engineer to be on site and expected modes of resolution of a problem is required.