ROTHAMSTED RESEARCH CEREAL TRANSFORMATION GROWTH ROOMS SPECIFICATION

1.0 REQUIREMENTS

1.1 The research conducted at Rothamsted research requires accurate and reproducible controlled environments for production of plants for producing developing seed embryos, notably from cereals but not precluding other plant species, for Transformation studies.

For the proposed research, accurate control of light intensity, day length, temperature, relative humidity and carbon dioxide 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 "growth room" will mean the total system, and the words "growing area" will mean the area within the growth room where plants are grown. "Growth height" is the maximum distance between the light barrier or lamp bank and the bench or shelf on which the plants sit.

Four to eight growth rooms, preferably six are required with a total growing area of between 25 and 35 square metres of growing area.

Energy consumption and lifetime costs are important to Rothamsted Research. An estimated energy usage is required for 4 situations.
a) All rooms running at lowest temperature 15°C 60% RH, all lights on mid-summer day (35°C ambient 50% RH).
b) All rooms running at highest temperature 25°C 70% RH, all lights off mid-winter night (-10°C ambient).
c) All rooms running at highest temperature 30°C 60% RH all lights on mid-summer day (35°C ambient 50% RH),
d) All rooms running at lowest temperature 10°C 70% RH, all lights off mid-winter night(-10°C).

Lifetime costs at 5 to 10 years to include maintenance and any replacement consumable (filters, lights etc.) costs at (a) 5 and (b) 10 years. All assuming continuous use on a 16hr day length.

The supplier should supply details and addresses of at least three growth room installations, with at least one of a similar design or room purposed for Transformation work, 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 design room exterior dimensions should be a maximum of 17.6 metres wide by 5.1 metres deep and 2.75 metres high. The rooms will require service corridor access of approximately 1.5 metres wide. A major constraint is the roof supports set at 3.6 metres along the length. There is a void space between of a further 0.5metres in height . There is an outside wall on the east side of the area designated for these rooms.

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 a drain. Because the floor will be exposed to water, nutrient solutions (>pH 5), soil, insect 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 Benching

Benching should be 0.6 metres high incorporating a flood bench with automatic irrigation (tap water), timer controlled, trays individually controlled, with drainage to drain. Benching should be adjustable in height from 0.3m to 0.6m. A growing height of at least 1.6m is required. Benches must not exceed 0.7m, accessible from one side or 1.4m accessible from both sides.

Width between benches a minimum of 900mm.

Flood benching, Staal and Plast or similar is required. A water limiter should be fitted.

2.7 Doors and Seals

Lockable access doors are required to rooms, preferably sliding as access is limited, to provide adequate access to the working area. A minimum access of 900mm wide and a height of 1800mm is required. To allow for observation of the plants or people in the working area without exposing them to the ambient atmosphere, the 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)

2.8 Other Access Areas

A minimum of two access holes to the room from the corridor for water, instrument leads and gas supplies. 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 access ports to be agreed.

2.9 Growth Room Sealing

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

2.10 Services

One double electrical socket on far wall of the growth room at 150cm from the floor is required, waterproof to IP 65. In the corridor 2 double sockets at each end of corridor is required. One tap supplying tap water, using a retractable hose (5 metres) with a water limiter (100 litres) and 'hozelock' fittings, should be supplied at far end, opposite door in each room. 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 100 micron particles and insects or bigger should be fitted. Filters must be insect proof. Air flows and air exchange should make allowance for this.

2.12 Service Corridor

A service corridor located on the inner west side of the area is required. A minimum width of 1.0 metre is required. Controls could be placed in the service corridor or in the inner main corridor.

3.0 ENVIRONMENTAL CONTROL

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

3.1 Temperature

The required growth room temperature range is 10^{o}C to 25^{o}C with no lights and 15^{o}C to 30^{o}C with all lights on. The maximum differential, as measured at the point of control should be less than +/- 1.0^{o}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^{o}C with respect to the control temperature, with or without the lamps on, across the room at 1.5 metres from the base in the room. This will be measured with a shielded aspirated temperature sensor at 4 points in the room, location to be agreed.

A maximum vertical temperature gradient of 2^{o}C with respect to the control temperature from the bench to within 30 cm. of the lights is required with the lights on, as measured at four points in the room, location to be agreed. 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 10^{o}C to 30^{o}C with lights on and off (where applicable) at intervals of 5^{o}C.

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/fridge plant must be on the east side of the building.

3.2 Humidity

Full humidity control to maintain relative humidity in the range 60 to 80% +/- 5% is required in the temperature range specified. 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.

Humidification alone is required.

Humidity stability must be achieved within 30 minutes of any control change, subject to ambient, assuming no more than a 5ºC temperature change or 20% change in humidity.

Separate day and night humidity control, including ramping is required.

3.3 Light

A light intensity of 1000 µmol at 30cm from the lights is required, still achievable after 2 years' use, 10,000 hours. A uniformity of +/- 10% over the growing area is required. Light uniformity is critical for this work. The preferred light quality is provided by OSRAM warm white tubes but alternatives using LED lighting or alternatives shown by the supplier to be suited for cereal transformation work will be considered, especially where energy usage is reduced. Lights should be dimmable and self-adjusting using a light sensor to a pre-set user determined level. The light sensor should be able to be adjusted to the height of the crop and moveable to respond to changes in crop height. A 10% supplement of far red is required, separately controlled.

A quotation is required for:

a) Lights as specified using colour 84 fluorescent lighting with a 10% supplement of far red, separately controlled.
b) Lights provided by LED lighting using Valoya NS1or similar plus far red.
c) Lights supplied as recommended by the supplier as suitable transformation work.

Suppliers should specify options including spectra, energy saving and cost of different lighting type as it relates to system cost.

3.4 Airflow

An airflow in the rooms of between 0.5 and 1.0 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 rooms 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 rooms should be on the basis of two air changes an hour, with an incoming ambient of 25ºC and 70% humidity.

Air extracted from the rooms should pass through a 200 micron filter. The filter should be accessible from within the room.

3.5 Carbon Dioxide

Carbon dioxide levels will be controlled in the range 400 to 1000ppm if required but levels will also need to be monitored in order to set fresh air exchange, supplementation is not used. A carbon dioxide supply will be provided. Accuracy of the sensor will be +/- 10ppm. The rooms will be alarmed as well, both at low and high level. A calibration schedule will be required.

3.6 Corridor.

This will require separate temperature control, using a simple room air conditioner with temperatures +/2.5°C and in the range 15 to 25°C.

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, carbon dioxide and lighting (main lighting and far red), with each environmental variable independently settable is required. The light level should be maintained at a set level using a height adjustable light sensor.

4.2 The controller(s) used will be capable of standalone operation independent of any external overseeing computer control and monitoring system. Any set points will be settable from the growth room. Visible displays of current temperature, humidity, CO_2 and set points where applicable for these to be available on the front of the room. In addition the status of the lights (% lights on) to be displayed. A controller will also control the flood bench system enabling different start times, duration of watering and up to three waterings a day for each flood bench.

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 The rooms will each require an energy monitor.

4,8 The corridor will require simple user thermostat for controlling the air conditioning.

4.9 All software must be capable of interfacing over the Rothamsted Intranet with various Rothamsted users.

4.10 Sensors should be logged at user defined intervals, stored and capable of being retrieved for analysis in an Excel compatible format.

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, carbon dioxide 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 growth 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. Whilst there is a preference for a chilled water system a direct expansion would be considered. Any refrigerant used must have a GWP of less than 2000. If rooms are not individually supplied with their own refrigerant system but using a chilled water system there must be redundancy in the system to allow maintenance.

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, the extremes of parameters specified above can be made. While this testing is underway, light intensity, light uniformity, pressure, 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.