Proceedings of the UK Controlled Environment Users' Group

1990 SCIENTIFIC MEETING

"CONTROLLED ENVIRONMENTS ON LIMITED BUDGETS"

Volume 1

Contents

L.D. Incoll (editor)

CONTROLLED ENVIRONMENT USERS GROUP

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The scientific part of the annual meeting consisted of three invited contributions summarized in the attached notes supplied by the speakers. (The Recorder accepts no responsibility for these notes least of all for the use of the antique unit lux!! He nevertheless thanks the speakers for supplying them.) The papers were of such interest that the Recorder's record of discussion points is very poor. He does remember the following.

1. It was felt that there was a requirement for Silsoe to do more work on air movement in "Budget" installations.

2. Fluorescent lamp end fittings must satisfy the H. & S.E.

3. Transistorised ballasts are approximately 50% the cost of ballasts with starters.

4. There was a prolonged discussion of running costs, total energy consumption, electricity tariffs, heat recovery, generating electricity (e.g. Liverpool University).

Following the formal meeting, the Group visited the Wye College Tissue Culture Laboratories, glasshouses and CE facilities.

RESUMES OF PAPERS

C.C. Hole (BSHR, Wellesbourne) **Growing room at Wellesbourne**

C. Hole spoke about the growing room at Wellesbourne which was installed in 1978 by Creemer Ltd, based on a design previously used at Long Ashton. It is built from sections of prefabricated insulation to form a room of 3 x 2.4 x 2.5 m (length x breadth x height) providing a growing area of approx. 6 m^2 and usable height of 2 m.

The room is cooled by two evaporator units hung from the ceiling and heated using the defrost heaters of these same units. Air is circulated by the fans in the evaporators, drawing it up through the ninety-six 1.5 m fluorescent tubes and 16 40W tungsten bulbs suspended beneath them and blowing it horizontally so that it eventually descends at the edges of the room and in the middle, between the two banks of lamps. Separate day and night temperatures are controlled with a Foster Cambridge "Clearspan" circular chart recorder linked to a Delta T psychrometer equipped with platinum resistance thermometers. Chilling is controlled via a 'hot gas by-pass' system and both heating and chilling are switched fully on or off. Recording is duplicated on a centralised logging system with thermistors housed in a 'home-made' psychrometer unit.

The room is also equipped with a fan and port providing fresh-air make-up, the facility for CO_2 supplementation, two spinning disc humidifiers mounted in diagonally opposite corners and a system for feeding nutrient solution.

A temperature range of 5-25°C is achieved with temporal variation of about 4°C around the mean and spatial variation of about 1.5°C as measured 0.9 m from the floor. Maximum irradiance at this height is approx. 90 W m^{-2} (350 umol m^{-2} s^{-1} PPFD) at 25°C with decline in output at lower temperatures (e.g. 60 W m^{-2} at 15°C), because the temperature of the fluorescent tubes is dependent on that of the room.

The room is presently used i) for raising plants for anther culture in a known and repeatable environment and ii) for screening plants for virus resistance in a specified environment. It has been found more reliable and less variable than temperature-controlled glasshouse compartments for these purposes. Physiological experiments on the effect of low temperatures on growth have been done in this room, but the considerable variation in temperature was a problem and necessitated the establishment of positional growth rate contours prior to examination of a range of genotypes.

(Note added by Recorder : capital cost is about 33% that of a Fisons Cabinet)

B. Roberts (BSHR, East Malling) **Construction of growth rooms at BSHR, East Malling**

B. Roberts gave a talk on the problems encountered in providing growth room facilities at BSHR, East Mailing and the technical solutions adopted.

Problems encountered included an initial under-funding for the size of facility required, finding a suitable building envelope in which to construct the growth rooms and trimming the ultimate scheme to meet the financial allocation in 1989/90. Two rooms were constructed with internal dimensions of 3 m wide by 2.8 m deep and 2.6 m high and fitted out with lighting rigs above each of six shelves to give irradiance levels of 250 µmol m^{-2} s^{-1}.

Whilst these levels of photon irradiance were achievable at 20°C, there was a noticeable reduction when the rooms operated at lower temperatures.

Both rooms were designed to work at temperatures down to 5°C with all 156 fluorescent lamps operating (8ft 100 watts) at an ambient of 30°C. The rooms were constructed with 100 mm thick insulated panels to which sliding doors and ceiling mounted DX coolers were fixed.

With the lighting control gear situated outside the growth rooms, refrigeration plant rated at 31,200 BTUs per hour provided sufficient cooling capacity to maintain 5°C with the compressors operating for 16 h in any 24 h period.

Numerous safety precautions were built into these rooms including high temperature cut-outs on the lighting and room heaters; audible alarm switches inside the rooms should staff need assistance; audible high and low room temperature alarms; oxygen depletion or enrichment audible alarms; residual current devices on electrical power circuits; bonding of all steel work and racking within the rooms; emergency door catch release mechanism.

Comparisons were commented upon between the cost of this 'walk-in' facility offering 30 m^2 of lit area at £29,500 and of three 'off the peg' cabinets bought at the same time for £30,000 offering a total of 5.6 m^2 of lit area.

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Finally colour slides of another installation of BSHR Hops Department, Wye were shown in which a Cindair humidifier had been fitted and operated successfully. The electrode boiling used in this type of equipment overcomes many of the problems associated with other forms of humidifiers and with legionnaires' disease.

Suppliers of equipment described in the talk were:-

Oxygen depletion and enrichment alarms
Electronic Devices,
48 Diglis Road,
Worcester.
Telephone: 0905-353555

High and Low Temperature Alarms
Future Electrical,
50-52 Churton Street,
London, SW1
Telephone: 071-821-7780

U.K. Agents
B.R.D. (Air Conditioning) Ltd.,
4 Summers Lane Parade,
London, N12 0LB
Telephone: 801-368-1203

R.E. Randall (BSLR, Littlehanpton) **Growing room at BSLR, Littlehanpton**

R. Randall standing in for J. Ross, described a room designed and built in 1989. Its summarised specification follows:

Size 3.168 m x 3.168 m outside giving 3 m x 3 m inside:

Height 3.2 m;

Walls 75 mm modular rigid polyurethane foam having an insulation factor of 0.0202 W m^{-1} $°C^{-1}$;

Floor 75 mm modular rigid polyurethane finished with heavy guage aluminium planking with a loading of 250 kg m^{-2}. A single door 0.915 m x 1981 m fitted. Two opposite walls were supplied at a height of 2.74 m, thus making access to the 'large house' 3 m x 0.25 m each side.

Lamp House Lamps were separated from the growing space by a double glazed SERAC panel. The panel is glazed in Melinex on the top side, and UV proofed TEDLAR on the lower side. This is because we use UVA tubes inside the room. The lamphouse is ventilated by a 45 cm fan fitted centrally in the ceiling drawing air through filters fitted in the two access holes. The fan is temperature controlled by an ON/OFF thermostat and can be manually speed

controlled for different light levels.

Air Handling Unit

Trembath TW10MK 2

Nominal Cooling 5.75 kW

Nominal Heating 3 kW

Air Flow 1700 $m^3 h^{-1}$ = 0.47 $m^2 s^{-1}$

Temp Range 0 - 35/40 °C

RH 30 - 95%

Defrost by reverse cycle

Specification

Temp Range 5 - 30°C ± 1°C

RH 40 - 95% ± 5%

CO_2 350 - 1000 vpm ± 5%

Lighting

Irradiance 50 W m-^{2} PAR at floor level
Higher levels obtained but not uniform

Sources 1) 72 x 125 W warm white fluorescent lamps
2) 9 x 100 W incandescent lamps
3) 6 x 40 W UVA lamps

All fluorescent lamps switched individually. Incandescent lamps switched in 3 groups of 3. All 3 types of lighting individually switched by timers.

SUPPLIERS

Rooms

Huurre Cold Industry Ltd
Unit 2 Caxton Road
Elms Industrial Estate
Bedford MK41 0HT |
0234 327855

Air Handling Unit (TW10)	Trembath Air Conditioning Equipment Marlowe Way Bedding ton Farm Road Croydon 01 689 4446
Lighting	Jerrard Bros Arcadia House 5 New Cairo New Road Croydon CR0 1XP 01 688 8222
Fans	Sifan Systems Ltd Northwood Road Windrush Industrial Park Witney Oxon OX8 5EE 0993 2929
Switches MK	Supplied by STC Distributors
Ceiling Panels	Serac Ltd Nyton Road Aldingbourne Chichester West Sussex
Enclosure	Eldon Eldon Electric Ltd Lovett Road Staines TW18 3AH 0784 61851
Control Gear e.g. Stats, Contactors, Relays	RS Components Ltd P O Box 99 Northants NN17 GR
CO_2 Flow gauge	Flowbits Freepost Basingstoke RG22 4AQ
Control MRB	Prospect House, Fir Tree Crook Co Durham DL15 8JU 0388 762272

D.W.W. Hand (IHR, Littlehampton) **Daylit growth cabinets at Littlehampton**

The eight separate and identical daylit controlled-environment cabinets, designed and built by Dr D W W Hand, are of external dimensions 1.22 m square x 1.63 m high. They are sited at

IHR-Littlehampton inside a mansard-type glasshouse for maximum light transmission. On overcast days the solar radiation flux density as a percentage of that outside is 68 within the glasshouse and 50 within the cabinets. Near the autumnal equinox the percentage for sunny days around noon can be as high as 80 within the glasshouse and 60 within the cabinets (DWH, personal observation). The reduced light flux density to the plants in the cabinets is a necessary cost of the protection provided by the outer covering of the glasshouse for the perspex inner cabinets, electrical and mechanical equipment, and personnel. Native herbaceous species growing outdoors will often experience higher light flux densities than those ordinarily possible in the daylit cabinets. The difference in light climate between the cabinets and the field situation however, is put into perspective by comparisons with light receipts at more northerly sites in the network of BSHR stations: during summer, the daily mean solar radiation receipt inside a daylit cabinet at Littlehampton (50°49'N, 0°31'W) is 65% of that received outdoors at Wellesbourne (51°12'N, 1°36'W) and 70% of that received outdoors at Cawood (53°50'N, 1°7'W).

Structural details of the cabinets have been given elsewhere (Acock, Charles-Edwards & Hearn, 1977), though modifications to the control systems for air temperature and atmospheric humidity have since been made to improve performance. Essentially, cooling and dehumidification of the air is effected by 373 W water chillers; these are located outside the glasshouse under louvred covers. Coolant is supplied to the cabinets at the desired dewpoint temperature and the air is then heated electrically to the required dry bulb temperature. Airflow is upwards at a rate of 0.4 m s^{-1}, measured at the base of the crop/plant canopy. This rate is a compromise between faster flows which cause a reduction in growth rate (Morse & Evans, 1962) and slower flows which increase the temperature gradient in the cabinet. Controls were set to maintain the air temperature in the cabinets at 18 ± 0.5°C night and day and, with the coolant temperature controlled at a dewpoint temperature of 11 ± 1°C, the atmospheric humidity in the cabinets averaged 0.7 kPa vapour pressure deficity (vpd; 70% r.h. at 18°C). On certain very hot afternoons the temperature in the cabinets rose 1-3°C above the set-point. A solution based on the Hoagland No.1 formula (Hoagland, 1948) and with an electrical conductivity of 1 mS cm^{-1}, was supplied to the plants growing the cabinets by means of capillary-watered slats (Wells & Soffe, 1962).

Four controlled levels of CO_2 enrichment, 350, 500, 650 and 800 vpm, were replicated twice. The CO_2 treatments were applied continously for seven weeks, commencing 23 July 1989. CO_2 was supplied from a bulk tank of liquid CO_2, and the control of atmospheric CO_2 concentration inside cabinets was achieved by conductimetric-type controllers based on a design by Begg & Lake (1968). Accuracy of CO_2 control was normally within + 3% of the desired value for most of the daylight hours. At night or in dull light, however, 'overshoot' produced by each injection of CO_2 reduced the accuracy of control and increased the variation in CO_2 concentration.

Analogue outputs from the CO_2 analyzers were monitored by a 'Datron' data logger equipped with an analogue to digital converter. Signal conditioning allowed the readings to be reproduced as actual concentrations of CO_2. The CO_2 concentrations inside the cabinets were scanned every 10 minutes throughout the experiment and the overall mean CO_2 concentrations for four CO_2 treatments during the seven weeks from 23 July until 9 September 1989 were 365, 496, 647 and 812 vpm.

A concise introduction to the climate of Sussex has been given by Potts and Browne, (1983). Climatic averages of air temperature, precipitation and bright sunshine for the period

1951-1980 were presented by Rose (1984) for the area of the West Sussex coastal plain in which the IHR is located. During summer, the Sussex coast is one of the warmest and sunniest areas of the British Isles. This reflects the continental component in the region's climate at this time of year. Further, sea-breezes often leave much of the immediate coastal area relatively free of clouds during the summer. The weather during the seven weeks of the experiment (23 July to 9 September) was characterized by above-average daily integrals of solar radiation and hours of bright sunshine per day. Incoming solar radiation (as measured outdoors by a Kipp solarimeter) totalled 860 MJ m^{-2}. This was 10.4% above the long-term average. The highest (25.01 MJ m^{-2}) and lowest (3.55 MJ m^{-2} daily radiation integrals were recorded on 4 August and 9 September 1989 respectively. At noon on cloudless days in late July and early August the maximum downward light flux density incident on the plants (as measured inside the cabinets by small, flat, cosine-corrected sensors having a reasonably 'square' energy response curve for the 400-700 nm waveband, see Fitter, Knapp and Warren Wilson, 1980) was 170 W m^{-2}.

Technical

Plant Floor area:	1.33 m^2; Height of plant space: 1.2 m
Incandescent lighting:	200 lx at plant height
Black-out covers:	<5 lx at plant height
Light transmission:	50% of that outside on overcast days
Carbon dixoide:	± 3% over range ambient to 2000 vpm
Temperature:	± 0.5°C (depending on season)
Relative humidity:	80-95% at 10°C and 50 - 95% at 30°C
Airflow:	vertically upwards at an airspeed of 0.4 m/s at floor level.
Leakage:	typically 0.05 - 0.1 air changes/h

L D Incoll
14 January 1991
M2/LDI/G3070