Secretariat Phytotronique
Phytotron C.N.R.S.
91190-Cif-sur-Yvette
France

Gif-sur-Yvette November 1976

PHYTOTRONIC NEWSLETTER N°14

Contents

I - EDITORIAL

Here is our 14th issue. As you may note, in spite of the difficulties which we still face, the volume of issues is increasing and we are able, at least in term of volume, to maintain our initial aim of three issues per year.

Our thanks to all the readers who write us such encouraging letters and to whom we often do not have the time to answer. However all the information that we receive is used and published in the Phytotronic Newsletter.

Our thanks also to all those who have sent or are sending us financial aid, whether it be personal, official or through a private organization. As always, we request that you address your donations to our intermediary with the endorsement : *" Participation aux frais de parution du Bulletin "Phytotronic Newsletter"* and writing out your bank cheques to the order of ;

A l'ordre de l'Agent Comptable secondaire du CNRS- 4ame Circonscription- 91190-Gif-sur-Yvette, France.

and postal cheques or money orders to the order of :

A l'ordre de l'Agent Comptable secondaire du CNRS- 4ame circonscription- CCP- Paris 9138 48 U, Paris, France.

o -

In the Table of Contents of this issue the four main chapter headings can be found covering a very large range of scientific, technical and economic subjects. We want the *Phytotronic Newsletter* to be eclectic, but above all, as polyvalent as possible.

Under the heading "Meetings" some were held in France and others abroad. Most of them show that economic problems are of primary importance in the subjects disccused at national (France) or international meetings (Switzerland or Romania).

We greatly regret that we are not receiving enough *news* about scientific or technical meetings which could be of interest to our readers.

Under laboratory news, there are numerous subjects and ideas concerning *Research Strategy.* We have, more particularly, extracted from the annual reports of three large Phytotrons information regarding their research orientation, we believe that the other headings also present subjects for reflection and of interest to our readers.

Under the heading *"Reports and Scientific papers"* we are publishing an article on economics which was sent to us, because we sincerely believe that it can provoke reflection and an exchange of useful correspondence directly with the author as he so desires. The other articles notes or reports present various fields of scientific and technical interest worthy of attention.

The last chapter is devoted to " *Miscellenaeous Information* " which evidently serves a useful purpose judging from the mail that we receive.

- o -

We would like to thank in advance those who send us reports of a scientific, technical or practical horticultural nature.

N. De Bilderling et R. Jacques

II. JUBILEE BOOK OF HOMMAGE TO PROFESSOR P. CHOUARD

On the occasion of the retirement of Professor P. Chouard one year ago, some of his colleagues decided to gather together a certain number of scientific articles, from French and foreign authors, in a volume dedicated to him.

The volume has been put together in such a way as to reflect, as much as possible, most of the scientific thought of M. Chouard, and the authors have been good enough to help us in this task. After an Introduction by Professor H. J. Maresquelle, articles of a biographical nature are found (G. Drouineau, J. Lavollay, C. Bressou, H. Gaussen) the ecological ones (P. Binet, M. Evenari, G. Lemee, D. Scheidecker and thier colaborators). Some general articles (R. Ulrich and P. E. Pilet) make up plant morphogenesis (V. S. Trippi, Y. Arnaud, G. Beauchesne, P. Champagnat, J. Guern, J. L. Hamel, H. Harada and their colaborators), then floral morphogenesis (D. Prat, G. Bernier, L. T. Evans, H. J. Maresquelle, M. Kh. Chailakhyan, S. J. Wellensiek). After C. Martin and F. W. Went the results of laboratory work at the Phytotron are gathered together. The volume ends with several research reports about photosynthesis (structure and functioning ; plant energy) (J. Aghion, A. L. Kursanov, R. Moneger, A. Moyse, A. Pradet andtheir colaborators) , the final article being a summary on phenylalanine ammoniac-lyase (P. Rollin and his colaborators). All of these writings constitute a volume of 44 articles in 672 pages, with many illustrations and figures; the exact title of this jubilee book is : *"Etudes de Biologie VOg4tale " Horivnage au Professeur Chouard* , R. Jacques . Ed. Paris. It will come off the press at the end of 1976.

We remind you that there is still time to acquire a copy by subscribing with a minimum amount of 100 Francs by postal or bank cheque made out to *"Jubilee Chouard"* (Banque BPROP, Account No. 19 19 11292 8) and sent to :

PHYTOTRON Laboratory
"Chouard Jubilee"
91190-Gif-sur-Yvette, France.

- o -

II bis. ERRATA - Phytotronic Newsletter Nos .12-13

In the article by G. S. Berson (Cultures in the Big North), page 45, line 24 should read: 400 000 - 300 000 and 150 000 m2 instead of 40 000 - 30 000 and 15 000

page 50, Table 2- Type of Lamps- should read :

3 rd line : $\Lambda P_1 + \Lambda$ 42 instead of $\Lambda P_1 + \Lambda$ 40

next to last line DPΛ- 400 instead of Λ DM 400

III. XIIth NATIONAL COLLOQUIUM ON PLASTIC IN AGRICULTURE

Hyeres, France, February 25-27, 1976.

Editor's Note : We have extracted some of the following remarks from the report published by the journal *Plasticulture* (March 1976, No.29 , pp.26-27) for our readers:

All the speakers drew attention to the shift from low tunnels towards walk-in tunnels and plastics structures. This is not really surprising, when it is realised that for most species it is the large unheated plastics structures which yield the largest profits: this is one of the striking conclusions drawn by M. Bry (ENSH-Versailles) from a long study comparing the growing of vegetables in the open field and under various forms of protection, in different regions.

MM. Wacquant (INVUFLEC) and Berninger (INRA) explained in the first instance, the substantial energy savings available to growers using greenhouses. In the ultimate, the use of plastics lead to a real revolution in the method of heating greenhouses and protective structures, as exemplified by the system of heating with warm water by heating ducts (MM. Marion and Le Flohic in collaboration with the C. E. A.) and the solar greenhouse (MM. Damagnez and Chiapale, INRA, in collaboration with the Centre d'Etudes Nucleaires).

Then followed papers from MM. Laberche (ITU Montpellier) and Spice (U. K) which underlined the savings in the usage of water, something which is becoming more and more scarce and expensive, obtainable by the use of plastics, as well as economies in fertilizer consumption.

Finally, the improvement in productivity due to the use of plastics is evident. All the lecturers , whether it be M. Guimbard on early potatoes or M. Agulhon (ITV) on vines, clearly brought out in their papers, which were bascially technical, figures in tons or in francs showing the plus values obtained by the use of plastics. It was learnt that in return for a reduced investment. 1 ha of dessert grapes grown in an unheated plastics tunnel in the Midi gave a gross return of 518.000 F as compared with 78.000 F for normal cultivation in the open. M. Paillier, President of the Chamber of agriculture of the Var, had already spoken highly of the mulching of vines.

Furthermore, plastics can be used as a substitute for the soil. Dr. Cooper described the system of cultivation on a nutritive film, which has *been* developed at the Glasshouse Crops Research Institute at Littlehampton, and showed that the technique can give yields of tomatoes of 320 t/ha (in a ten month period).

The proceedings will be published in due course, by the: Comite des Plastiques en Agriculture, 21 rue Pinel, 75013-Paris.

- Q -

IV. SOLAR ENERGY: PERSPECTIVESFOR A BETTER UTILIZATION IN HORTICULTURE

Meeting in Avignon (France). May 7 , 1976

Editor's Note. Since many countries are faced with important and pre-occupying energy problems it would be of interest for our readers to read certain passages from a review of this meeting published in the French Journal *Pepiniristes, Horticulteurs, Maraichers (PRAP-August-September 1976, pp.23-29) :*

In an introduction to the technical discussions, M. Moyse, Professor at the Science Faculty in Orsay, Vice-President of the A. F. E. D. E. S., shows that it would be of interest to reduce the heating requirements of greenhouse cultures (on the order of 20 to 30 t of fuel per hectare per year) by traping infra-red solar rays not utilized by the plant.

Thermic Requirements of Plants. Mr. Jacques, Assistant Director of the Phytotron in Gifsur Yvette, is attempting to specify the thermic requirements of plants, such knowledge being fundamental for a rational utilization of energy :

Thermoperiodism must be considered according to different time scales :

-the year with its seasons: seasonal thermoperiodism.
-the day with its alternation of light and dark : daily thermoperiodism, with day and night.

Its action differs according to whether it is applied :

-to the aerial part only of the plant
-to the underground part only
-to both, each with its own regimen.

As a matter of fact, if the different functions on which temperature acts are well localized, an action on one of them, reacts on the entire plant.

Bulb plants illustrate very well seasonal thermoperiodism:their development is regulated by succession, at the level of the bulb, above all by a fairly high temperature for floral initiation, then a cooler one for put an end to the dormancy of the following year.

As regards daily thermoperiodism, Mr. Jacques notes first of all the difficulty for an experimentor to find a criteria making it possible to measure the effect produced by the regimen of the temperature being studied, in other words to find an element of the plant, which reacts to the variations of thermic conditions in a noticeable, regular and easily measured way.

The essential conclusion of this interesting exposition then is that the scientific experiments which made it possible to understand thermoperiodism and to specify it can not be used to establish a precise temperature state to be used by practitioners.This introduction of a physiological nature is succeeded by technical accounts essentially dealing with various methods in collecting solar enery for agricultural ends.

Traping Solar Energy by Plastic Ducts.

Mrs. Fourcy and Dalle recall that the principle of heating ducts consist in circulating water at a low temperature in supple plastic ducts disposed flush with the ground (as mulching).

The low level of water temperature (in Grenoble it varies from 28° to 35°C) is compensated by the large exchange surface of the ducts: these occupy more than 50% of the ground surface. Holes in the ducts as in classic mulching, but taking care that they are water-tight , makes it possible to reach normal densities: e. G.64 lettuce /sq. Meter.

Aside from specific cultural results, the system was of great interest purely on an energetic level :

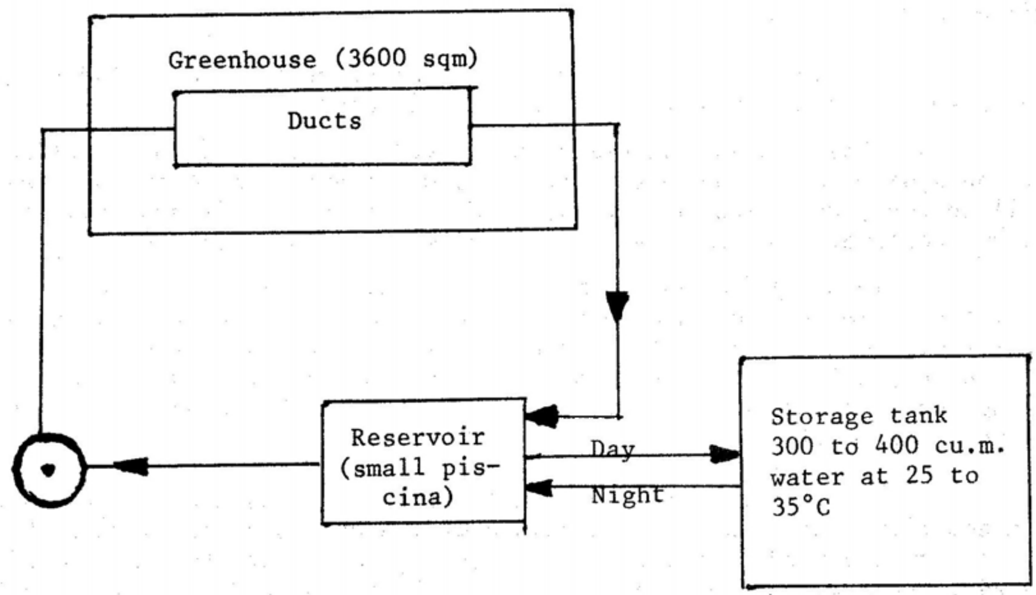
-ducts constitute good collectors of solar energy (when plant are incompletely developed): in sunny weather, the temperature is higher at the exit than at the entrance of the ducts. A good use of this heat implies a storage, in order to restitute it to the greenhouse when exchanges show a deficit ;

-the thermal inertia of the greenhouse is noticeably increased with regard to classic methods (hot water pipes, hot air) due to the fact that :

- -the soil that contributes more,
- -the water mass being used is very high, as is the exchange surface.

The possible mobilization of this large quantity of heat lessens temperature variations at the plant level.

Block diagram of the installation :



In the daytime "heated" water in ducts is sent to a storage tank at a maximum temperature of 25-35°C in order to avoid calorific losses.

At night the ducts are fed by inversing the direction of circulation of the stored water towards the reservoir, with a difference of usable temperature in the order of 10°C. If the amount of daytime sunlight is too low, one can add to it artificial heating.

In Grenoble in favorable conditions only about 10% of solar energy would be collected (this proportion diminishing as the plant cover grows).

Adapting conventional solar collectors to greenhouse heating

Mr. Abran's heating system consits of a watertight circuit in which water circulates. The water is heated in solar collectors and is diffused throughout the greenhouse by aerotherms; the device comprises, furthermore, a pump, a reservoir, a regulator.

The collectors are flat, thin slabs in which water circulates. They cover about one-fourth of the cultivated surface but it is hoped to decrease it to on-fifth.

Aerotherms were chosen to function with the water supply at 50 °C. This diffusion through aerotherm is not obligatory , the system being able to operate also with classic warm water tubes, ducts on the soil, etc.

The reservoir makes it possible to :

-store the heated water for ulterior use,
-complement water heating for collector insufficiency.

Results- the energy collected makes it possible to cover 56% of the requirements of the culture being studied, thus an energy saving of the same order.

Solar air conditioned greenhouse

Mrs. Damagnez and Chiapale of INRA presented a new kind of greenhouse using solar energy as a source for heating and air-conditioning.

This development has been adapted particularly to the climatic conditions of the Mediterranean regions, where it is necessary to heat greenhouses ar night during all seasons, while during the day, even in winter, it is essential to use ventilation and cooling in order to avoid excessive rises in temperature.

In the solar spectrum, the wave-lengths used for photosynthesis are found in the visible part and the infra-red radiation only goes bo increases the temperature inside the greenhouse. The research team had the idea of using a selective filter which only allowed the radiation for photosynthesis to pass through and of controlling the temperature of the crops inside the greenhouse by the control of the temperature of the wall.

This filter is a double wail filter (in plastics) , through which a heat-exchange liquid circulates and accumulates the excess energy during the day: the infra-red energy absorbed is stored in a reservoir. At night, the energy which has been accumulated in this way is released at the wall level for the heating of the greenhouse.

Such a system has the additional advantage of considerably reducing the water consumption of the crops (about 65 p. Cent in comparison with external conditions) and is particularly suitable for those regions where water is scarce. It is intended to use the system in association with a desalination plant for crop production in arid zones.

The system has been patented in May 1974.

Lifting Energy bosses in greenhouses

This was the theme of the last report, that of Mr. Gac, Assistant General Director of C. T. G. R. E. F. He noted mainly that:

-the greenhouse calls for different modes of energy transfer; radiation, conduction, convection;
-the interactions between supplies and losses implies that heating a greenhouse necessarily leads to a dissipation of heat towards the exterior ;
-plants are not energy transformers as motors or heat generators.. and warm-blooded animals which transform a chemical or electric energy, etc. into heat...; to increase their temperature, they need to be directly furnished with heat or else energy which can immediately down-graded into heat (radiation).

He analyzed next the behavior of greenhouse walls with respect to three possible modes of losses: radiation, conduction, convection.

For greenhouses, one looks for :

-maximum transparence to visible radiation
-minimal transparence to infrared radiation

As concerns conduction-convection exchanges, with very thin separations utilized in the greenhouse, convection phenomena are predominant with respect to those of conduction, whether it concerns exchanges through :

-the material of the separation itself:
-or the separation openings.

He concludes that to save energy one can act upon, practically, on the following items:

Radiation

Reduce infrared losses thanks to the use of :

-separations opaque to I. R.: thus, the advantage of glass;
-antiradiant screens;
-separations reflecting I. R.; although transparent to visible radiation;
-reflecting walls (aluminium);
-infrared heating of the soil.

Favor collecting solar energy and its accumulation either on a daily scale (day-night) or on an annual scale (summer-winter).Thus, the interest of the various systems presented, namely the solar greenhouse.

Conduction-convection

The reduction of these kinds of losses leads to :

a) an increased insulation of greenhouses thanks to the use of:

1)double separations (these must stay well separated in order not to create a thermic bridge: not easy to do with films);

2) "bubble" separations.

these insulations being able to be localized above the aerotherms, for example, on the north side, etc.;

b)a reduction of convective exchanges :

1) externally by means of a wind-breaker;
2) between the interior and exterior , by a good tightness.

In many cases, an action on the three items :"tightness reflector screens, doubling of the separations" could be immediate and very effective(the requirements often would be able to be reduced by half).

In conclusion, Mr. Bord, Director of FORMA, indicated the main lines of action for aiding research.

Three lists have been established for work:

1)those which led to definite results and able to be immediately transposed into practice: the means necessary for immediate exploitation must be outlined;

2)those which are well advanced but where the results have not yet reached the preceding stage: to accelerate them towards this objective ;

3) those which can be developed because of the benefits expected: to coordinate these actions.

V. ISHS SYMPOSIUM ON THE VEGETABLE PRODUCTION IN GREEHOUSES I

Bucarest-Romania-18th-22nd may 1976

Miter's note. This Compte rendu was an abstract of a note published by A. Bry in *Plasticulture* N°30 (1976 june p.3-8) and in P. H. M. (1976 july p.43-45).

The programme which occupied two days was divided into a number of sections.

The section for genetics, breeding and seed production has concentrated on the work carried out in the Eastern countries and particularly in Rumania on the production of seeds intended for growing in protective structures.

Cardinal points :

production. . The development of F_1 hybrids of peppers particularly suitable for early

. Several reports have been presented on the development of new varieties and hybrids of tomatoes .

The physiological and nutrition section considered several reports dealing with different methods of fertilisation and the various nutritional properties of the resulting produce.

A report from the Technical University of Munich has indicated that the concentration of vitamin C in tomatoes decreases with a reduction in the light intensity and also that differences in concentration exist within different sections of the fruit, thus sections exposed to the south are the richer in vitamin C.

It was evident from the reports presented from the various countries that researches were directed to improved irrigation and fertilisation on the one hand by the control of the water and fertiliser supply and the introduction of new methods of crop irrigation on the other.

In the more Northern countries, particularly in Sweden and Poland there has *been* marked interest in improved production both by research into different soil mixtures and also by cultivation using mineral solutions in a peat bed (10-15 cm) supported on a plastics film. For example, in 1976, 10 p. Cent of the tomatoes will be produced using this system.

The section for technology, mechanisation, construction and microclimate considered the various factors arising with cultivation in the greenhouse :

. The interest in drainage (1.500 ha of crops grown under protection in Rumania are drained);

. The comparison of different systems of irrigation;

. The interest in the enrichment of the atmosphere with CO_2 for red peppers :

. The automation of the control of the atmosphere in greenhouses (temperature and hygrometry).

In the section for plant protection, many papers have been presented, covering the all aspects :

The work described in this section by the Rumanian reporters clearly show the difficulties which have to be overcome in the area of phytosanitation with the rapid development of cultivation under protection.

It is of interest to draw attention in the sections for packaging, transport and commercialisation to the results achieved in all the socialist countries on the following aspects :

. Improvement in the presentation of products;
. Strict programming of production based on consumer demand:
. Customer surveys on the quality of the products presented.

The programme of visits

The delegates were able to appreciate the efforts being made on cultivation in protective structures in Rumania on trips in the area of Bucharest and during a tour through Brasov, Sibliu and Craiova: 48 ha in 1960; 1 188 ha in 1976. It is programmed to increase this to 2 204 ha by 1980.

The basic principles for the development of greenhouses in Rumania are:

. The planned development of agriculture and in consequence of horticultural production;

. The economic use of the heat obtained from power-stations, thermal power-stations, heavy industries, etc.;

. The concentration of the areas of greenhouses into large or very large undertakings.

Area of a site (ha)	1-5	5-10	10-50	50-100	> 100
Number of sites	80	11	16	3	3
Total area (ha)	167	72	281	195	473
Percentage	14,1	6,1	23,6	16,4	39,8

The published average yields, obtained in two production cycles (January to July and August to December) are as follows :

- tomatoes :120 to 140 tonnes/ha ;
- cucumbers :240 to 250 tonnes/ha;
- peppers :50 tonnes/ha.

The greenhouses are grouped together in blocks of 6, 4 and 2 ha.

The average work-force units per hectare (WU) is of the order of:

- 10 WU for cut flowers (carnations and roses);
- 5 WU for tomatoes;
- 6-7 WU for cucumbers, for which the new method of pruning has not yet been adopted.

In Rumania, there are about 3 700 ha of crops grown under protective structures, which are distributed as follows:

- 2 000 in co-operative;
- 1 000 in State undertakings;
- 700 in privately owned undertakings.

This symposium, which lasted for five days, was attended by 300 delegates of whom more than 100 were of other nationalities. About one hundred reports were presented and these gave a complete picture of the state of development of the cultivation of vegetables under protection in the different countries and particularly in those in the socialist economies where considerable efforts have been made over recent years. The proceedings will be published by the International Society for Horticuftural Science, Bezuidenhoutseweg 73, The Hague (The Netherlands).

VI. 7th MEETING OF COMMITTEES "PHYSICS OF GREENHOUSES" AND "CULTIVATION UNDER PLASTIC"

St Pol de Leon, France, June 1-3, 1976

These committees meet every year to take up different technical problems, new heating systems for shelters and to examine the different experiments done in France. This year more than 50 specialists in the fields of research, teaching, development, application and industry were very graciously welcomed by Mr. C. Guimbard, Director of the Domaine Experimental de la Ceinture Doree in Saint Pol de Leon to meet with
representatives of producers, cooperatives or trading firms. The two working days deveoted to study were followed up by a visit to 4 areas under cultivation near Brest.

The committees discussions of course were devoted mainly to problems of economizing energy. Without going into details of the various subjects brought up, here are just a few remarks on which discussions were based and which had not been mentioned in the minutes of the other meetings on economic savings in Hyeres or in Avignon, which are discussed elsewhere in this bulletin.

i)Greenhouses and transmission coefficient

At the end of 1975 France will have:

Glass Greenhouses:	Total: 1000Hectares = Unheated-30 Ha + Heated 970 Hectares
Plastics Shelters	Total: 1700 Hectares = Unheated 800 Ha + Heated 900 Hectares

or 1870 Hectares of heated greenhouses or shelters.

In Avignon the following energies expressed in Kcal/sq. Meter/day were noted:

	November to January	February to April	Summer
Incident energy	1500	3200	5700
Stored energy therefore recoverable	600	1300	2300

In mean hourly value the energy (expressed in Kcal/hour/sq. Meter)calculated in terms of the fluid used between the walls of the solar greenhouse, was :

	Pure Water	$CuC1_2$ 1%	$CuC1_2$ 2%
Average for 5 days	87	129	147
Average for 3 favorable days	120	135	188
Increase of T° at pool level for an average of 3 days :	9°	11°	14°

Average monthly values of the transmission coefficient in % of exterior solar radiation for the period October-December in the region of Grenoble-Avignon was :

	Total	Infrared	Visible
2 glagges without water	61	60	61
2 glasses with water	55	42	70
2 glasses 4- $CuC1_2$ at 1%	36		
2 glasses + $CuC1_2$ at 2%	25	5	50

Inside, high daytime temperatures on the soil are avoided with a solar greenhouse, as well as a part of the soil radiation being suppressed, therefore minimum nocturnal temperatures will be higher.

In general in the diverse greenhouse experiments at the very least it is necessary to measure the ambient temperature at the leaf level, because if not able to measure the surface leaf temperature by radiometer, which is a very costly method, the former one is necessary in order to try to appreciate and explain the results obtained.

Instead of incorporating copper chloride in the water it can be incorporated as a filter in the glass, or else, can be utilized as small glass balls of 40 to 100 **p** which are included in the plastic and using ordinary water, which facilitates isolation techniques.

The use of a surface treatment for the glass to stop infrared radiation, while letting the maximum visible pass, must be realized on the interior of the glass, in order to avoid its elimination by the water.

2) Heating by Ducts

Under a tunnel or in a greenhouse several problems arise:

Avoiding the formation of air pockets in the duct, which stops or slows down water circulation.

The duct heats the soil which provokes the development of flora and fauna, necessitating surveillance in order to avoid damage to the cultures.

The percentage of soil covering, between 40 and 70%, depends on many factors, primarily the culture.

The ducts must be able to be easily removed for the winter;their lifetime should be for 3 years.

An important problem resides in a simple method of cleaning the ducts, primarily for cleaning the algae which normally is concentrated in the storage pool. The use of a disinfectant, for example of quaternary ammonium, risks provoking the destruction of soil fauna and flora.

3) For mulching with plastic for which there were in 1975 about 34.000 Hectares in France, for 11.000 Hectares of half forcing cultures, colored material (opaline) is used more and more often and experiments with photodegradable material are underway.

Perforated plastic with holes of 1 mm, up to 500 per square meter, for Lettuce makes it possible to withstand freezing up to -7°C with sprinkler watering in case of frost.

Mulching in greenhouses is also being developed in the Rhone region in order to reduce weeds cleaning, and inconvenience being that more watering is necessary in this case. The question remains as to whether the reason for this need is due to heavier evaporation or to greater percolation.

4) Experiments with cultures in bags (Gro-Bag Fisons) have been done in several regions (0rl6ans, La Baule, Angers) on Tomatoes in the ratio of 3 plants per bag of 47 liters of peat and fed by a fertilizing solution. Price of a full bag: 10 F (Tax Ecluded *)d,* more important experiment will be taken up next year with the establishment of an economic balance.

According to English growers in Guernesey a savings is made in the manual labor saved and in a harvest which is 7 to 10 days early.

- o -

VII. OGA - 9th SWISS HORTICULTURAL AND ARBORICULTURAL FAIR I

Bern, Switzerland, June 23-24, 1976.

Editor's Note. We are reprinting some of the following information for our readers which appeared in an article by Mr. C. Moncousin in *PHM July 1976, pp. 125-126.*

The 9th Swiss Horticultureland Arboricultural Fair took place June 23 and 24 at the Horticulture School in Oechsberg (Bern). This exhibition brought together 350 exhibitors, 25 from foreign countries, on an area 26.000 square meters large of which 2.500 square meters were covered.

The main attraction of the exhibition without any doubt was the solutions proposed by the three main Swiss manufacturers of greenhouses and glass shelters to the delicate problem of calorific losses.

The GYSI company noted that in the region of Zurich :

-nocturnal temperature should not be thought lessly lowered, particularly after a day of high luminousity for metabolic reasons.

-reduction in volume of the greenhouses did not allow an energy saving because the reduction of exchange surfaces was compensated by an increase of hourly air renewal and an increase of condensation.

-soil heating made it possible to diminish losses through radiation but it brought about important losses by increasing the evaporation rate of the environment which almost equalled a waste of energy.

-integral lining of greenhouses allows for substantial energy savings :

60% for lining with Styropor plates
41% for lining with plastic alveole sheets
36% for lining with glass (double glass)
31% for lining with PtV sheets
16% by covering interior shading with material at night, but these solutions greatly reduced light and were difficult to implement.

The GYSI Cy-proposes: to paint heating pipes close to walls with a paint made of aluminium oxyde (a 25% savings on fuel consumption was registered by the GYSI company),

-mounting aluminum sheets under the ceiling glass: these sheets are attached to the frame and cover about 50% of the surface. The surfaces that are left uncovered during the day can be covered during the night by sheets driven mechanically (the moveable sheets are covered by the fixed plates during the day). Energy savings should be 30% in the first case and 45% in the second. The device serves also for shading without interfering in the spectral composition of the light (tests are presently being done with Cyclamen and Euphorbia pulcherrima cultures by Haller Firm in Brugg (Argovie).

The Becher company proposes a more original and more complete solution since it has developed a new type of greenhouse called ECOGAL. These greenhouses are characterized by :

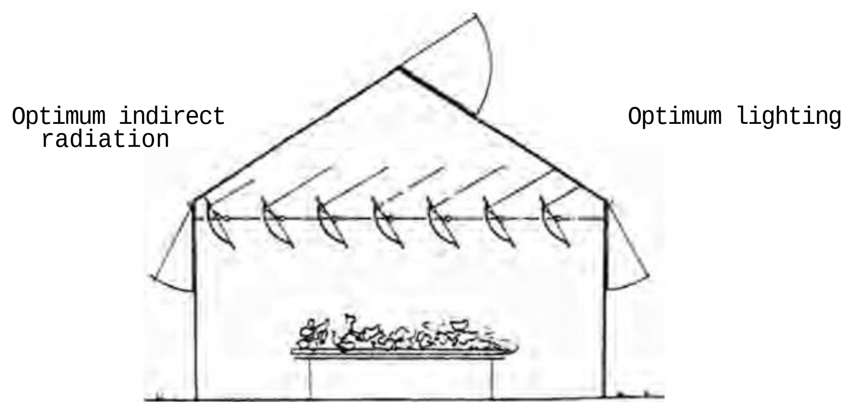
-straight sides fixed and very high (3 meters)
-interior shading on the entire surface
-skylight ventilation (50% of the ceiling is moveable-
-a double acrylic glass covering(sheets of 3 000 x 900 mm) fixed on the framework by PCV pieces to prevent any thermal bridge. The savings registered was about 50%; furthermore, non particular dirtiness of the double acrylic glass was noted in spite of the absence of air-tight joints between the two sheets.

The Allenspach company presented a still more interesting realization in collaboration with the Polisolar company :

Internal shading is installed inside the greenhouse which is made up of cylindrical parabolic mirrors that are moveable and are placed longitudinally around pipes placed at their focus. These collectors can occupy three characteristic positions and all intermediate positions:

-when solar radiation is intense and a shading is necessary, the collectors are oriented towards the sun. They concentrate the solar radiation at their focus on the absorption piping and the fluid which is contained in the piping is heated; the fluid is driven by forced circulation into an accumulation reservoir. Therefore there is no thermic accumulation in the volume included between the greenhouse ceiling and the shading since calorific energy is collected.

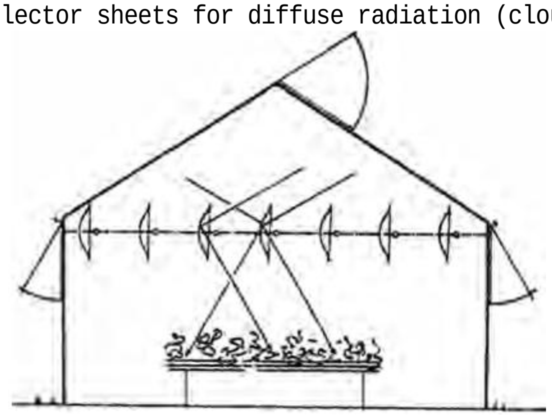
Position of the collector sheets for collecting solar energy and for shading the area cultivated.



-when radiation is essentially diffuse, the collectors are placed vertically and are used as were the mirrors.

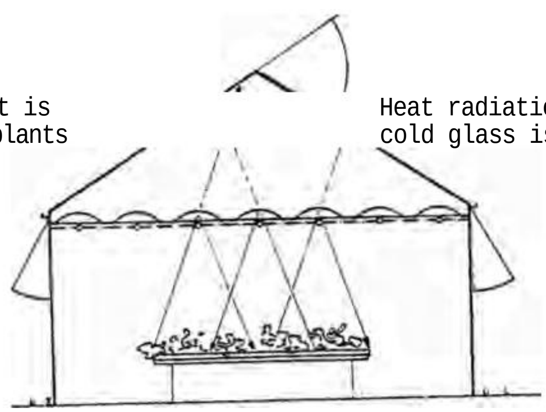
Lighting is thus increased to about 15% at the level of the cultures.

Position of the collector sheets for diffuse radiation (cloudy sky or rain)



-during the night, the collectors form a "roof" above the piping and serve as reflectors for the calorific energy distributed by the latter (the fluid used is that which had been heated by the sun during the day and kept in reserve) (see illustrations).

Position of the parabolic mirrors of the collector
during the night



This realization is particularly valuable for regions with much sunlight **and** with cold nights such as the Valais region, but horticulturists consume warm water in all regions, if only for daily needs

This very interesting exhibition is held every two years.

Those interested in receiving additional information should kindly write to : Professor Ch. Moncousin, Technicum Horticole de Lullier, Ch.1254, Lullier, Switzerland.

VIII . ACTUAL RESEARCH AT THE C. N. R. S. PHYTOTRON IN GIF-SUR-YVETTE, FRANCE I

Director : Professor P. Champagnat
Assistant Director: Dr. R. Jacques
(Honorary Director: Professor P. Chouard)

At the request of numerous readers of the Phytotronic Newsletter we are taking out of the Scientific Activity Report (June 1976) (for internal use) the information cited below, which we hope will satisfy those who would like to know the research orientation and the results obtained at the Phytotron in Gif-sur-Yvette.

For nearly fifteen years the Phytotron has been operating without intervention and its use as a tool with all of its' qualities as well as its' imperfections and limits are well known. The upkeep of the entire installation is assured by a qualified and competent staff.

Farther on we will give a list of ongoing work and under the heading "articles in print" in this issue, articles published by the staff can be found.

As the Reports shows, the scientific activity can be divided into 7 parts.

I. THE PHYSIOLOGY OF FLOWERING

The varied aspects of the physiology of flowering which are taken up in the Phytotron reveal the complexity and the long-standing interest in the problem by this Laboratory. **First** of all the researchers'work was dedicated to the study of a relatively large number of plants in order to focus on their characteristics expressed quantitativein relation to environmental factors. Then their activity progressively became oriented toward a thorough study of a more limited number of models. However, a give and take relationship between comparative studies and experimentation must continue to exist in order to prove that the hypotheses are well-founded. Obviously, the experimental possibilities at the Phytotron lend themselves well to this approach.

The effect of two environmental factors on flowering light and temperature, can be studied in a privileged manner. Their influences can be considered alone or together. It is in this way that the respective role of photosynthesis and reactions governed by the phytochrome system on flowering are the purpose of studies done particularly on *Anagallis arvensis* . The action spectrum done in weak energy light on *Calamintha* and two species of *Blitum* , all long day plants, lead to a way of specifying the morphogenetic reactions of different plants of this category.

As for cool temperatures, their effects at the beginning of a plant's life have a very distinct influence on growth and ulterior floral development, even in a species
with very low requirements (Maize). A study of the interaction of these two factors shows the importance of low temperature which makes it possible for a short day plant (Perilla) or certain long-day plants to flower in a non-inductive photoperiod, although Calamintha (long day plant) does not present this phenomenon.

Some experiments modifying the organization of plants placed in a stable environment and unfavorable to flowering made it possible to uncover the system of inter-morphogenic influences which regulate plant or floral development *(Scrofularia arguta* and *Chanopodium polyspermum).* This method of approach has been rapidly extended to experimental situations integrating the photoperiodic requirements of the plants being considered. Thus, it may be asked what the barriers to flowering are (e. G. roots)raised about by environmental conditions. Numerous inter and intraspecific grafting experiments show that floral stimulus is not specific *(Blitum, Chenopodi%o, Bryophyllum)* but that its synthesis takes place in two stages even when flowering is obtained without a classic sequence *(Bryophyllum daigremontianum* and *tubiflorum).*

The carrying out of the flowering process was for a long time thought to be essentially dependent on an external factor (temperature or photoperiodism) or an internal one (florigene). For some time now, the essential role of interactions, as well as external factors (concepts of primary and secondary induction)and internal ones, have appeared in a different light. Some points, concerning these interactions, are undergoing study and are attempting to integrate these two levels. Thus, the cold, applied to plants placed in non inductive photoperiodic conditions , act upon the leaf, bestowing on it a transmittable state by grafting, analogous to that obtained by inductive photoperiodism. Cold and photoperiod, then, have the same point of impact. A definition of this state of competence (definitive acquisition of the induced state) is
the object of studies dealing with, for example, the difference of photosynthetic activity (Perilla). As concerns receiving a signal, interactions can also be brought to light. In *Anagallis arvensis* , for an equal induction, variations in territory receptivity appear. They correspond to a stage of meristem development, characterized morphologically and histologically. Cytologic studies should be undertaken, keeping in mind the quantitative aspect of the morphogenetic expression of the phenomenon.

Studying interactions between organs is done in the context of different environments. It is identified with a conception of flowering that is based upon modification of the stimulation-inhibition balance during plant ontogenesis, which can be expressed at the hormonal and metabolic levels.

The knowledge acquired and the technical means available at the Phytotron allow for the study of specific problems of agronomic research (e. G. Growth, flowering, fructification in Maise and Pepper).

II. CONTROLLED MORPROGENESIS

Studying floral or vegetative change in an entire plants has led to certain working hypothesis based on the idea of equilibrium and of correlations more than on a specific induction.

The data obtained on simplified experimental systems confirm these hypotheses. Indeed, it has been revealed on numerous systems that a rupture of correlations by excision makes possible expression of morphogenetic capacities which up till now remained concealed, or even, new ones to express themselves (e. G. Formation of unicellular hair by the epidermic cells of leaves in Begonia).

In addition to the determining role of correlations between organs, the great influence of intertissular correlations and cellular contacts exerted on the expression of morphogenetic potentialities has been shown. It would be interesting to learn now cambial formations in Tobacco "recognizes" the presence of superficial formations to express their capacity for forming flowers *de novo.* Outside of biochemical considerations, it would be useful perhaps to study, at the level of cellular contacts, the modifications of membrane exchanges provoked by excision. It seems a well established fact up till now that an injury is necessary to disclose morphogenetic expression. Yet in Begonia it was shown that the capacity for forming buds and roots *de novo* can be expressed- without any previous injury - in entire leaves still attached to the mother plant.

The fact of being able to obtain buds, either directly on isolated formations, or indirectly after formation of a callus, could be profitable for completing an analysis of genetic variability already done by certain authors on Lettuce. As a matter of fact they used plants regenerated only from buds developed on calluses. A more complete analysis on genetic variability could eventually be undertaken. One would be able to compare plants descended from classic cuttings, from stem fragments after callus formation, from isolated epidermal formations, from isolated epidermal formation having earlier produced a callus, from callus coming from isolated cells, directly from isolated cells, from protoplastes, *etc...* Of course, an interpretation of the results will be made difficult because of possible effects due to the transition from the culture in *vitro* to the greenhouse.

The roots formed directly from thin layers could eventually serve as study material to determine the variability of the chromosomic number of organs issued from the tissue culture (superficial or underlying).

The fact that a combination of three single factors given in variable doses makes it possible to orient at will the morphogenic expression of cytologically differentiated cells, proves the importance of the quantitative aspect of the regulation of morphogenesis. This is also well proved in the whole plant as well as in simplified experimental systems. Experimental demonstration is however clearer in the latter given that :

-the possibility of passing from one program to another and vice versa by simply modifying this equilibrium ;

-a great sensibility and a great rapidity of reaction (8 to 10 days or 2 to 3 weeks to form, respectively, Tobacco and Endive flowers from cytologically differentiated cells instead of from a few months to more than 2 years).

So we are no longer dependent upon the normal life cycle length of an entire plant in order to intervene on plant and floral changes.

Finally, although there are great differences between entire plants, fragments of organs, isolated cellular formations and isolated cellsyare still capable of "simulating" the entire plant in the expression of its diverse morphogenetic potentialities, in spite of their apparent simplification. It would seem that a comparative study of morphogenesis at diverse levels of integration is as necessary as a global study of morphogenesis on the level of the entire plant.

III. PHYTOCHROME AND PHOTOPHYSIOLOGY

Most of our current knowledge about the phytochrome was obtained from observations done on etiolated plants and numerous action spectras of the light must be undertaken on green plants to aid in understanding the mode of action of the pigment. Research is focused on an analysis of action spectras of light via the phytochrome on morphogenesis and for that three models of study have been chosen :

1. Growth of Internodes of Stems

The action of light on the growth of stem is measured by the lengthening of internodes of *Chenopodium poiyspermum* , cultivated at 22°C and submitted, by 24 hours cycles, to 9 hours of trophic lighting (100 W. M^{-2} and 15 hours of monochromatic lighting of weak energy (0.5 W. M^{-2}).

The action of the phytochrome is not constant during the 15 hours period: inhibition by red lighting (R) takes place in the first hour and between the 7th and the 12th hours, while stimulation by far red lighting (FR)is essentially limited to the first 7 hours.

The phenomenon is a complex one to study: the internode is a very important photoreceptor site for the stimulation of its own elongation, but photoinhibition depends upon the other aerial organs of the plant (leaves and apex).

One of the original aspects of this work was to maintain the phytochrome in its inactive form during periods of darkness the plants receiving 15 minutes of FR before each dark period (P660) and after each monochromatic lighting. This methodology (very rarely, if not ever used by other authors) is essential, taking into account current knowledge relative to the phytochrome and mainly, its spectral properties, the existence of intermediate states during phototransformation P660 to P730 and P730 to P660 and the diminution in the time of the Pactive /P total ratio which is high at the beginning of a dark period.

Selective lighting of leaves is currently under experimentation and its effect measured on stem growth and on the growth of lighted leaves. For this purpose we are using two original technical devices: optic fibers adaptable to a spectral illuminator (band width of 10 nm maximum) and electroluminescent diodes (band width of about 20 nm and A max = 644 nm).

2. Floral Induction

A. for a short day plant, *Chenopodium polyspermum L.*

In comparison with the effect of light on stem growth, variable during a 24 hour cycle, the effect of the inhibitor lighting for flowering is measured during the 15 hours which follow the trophic lighting. The phytochrome only inhibits flowering in the period between the 7th and 12th hour. The experiments being done aim to seek the minimal period of effective lighting and its eventual shift in time by anterior lighting, and this, in order to better understand the localization in time of the effectiveness of the light and its dependence(or its independence) in regard to the active phytochrome.

B. for a long day plant , .

Calamintha officinalis.

The action spectra obtained shows the great effectiveness of radiations R on floral induction, which does not coincide with the maximum around 700 nm found for other long day plants tested in the laboratory *(Blitum capitatum* and *virgatum, Lolium temulentum* and *Anagallis arvensis).* Induction can be obtained by only one 24 hours phoperiodic cycle, but the minimum number of photoinductor cycles necessary for induction, as well as the peak position of action, depend on the trophic lighting value in the several days which precede the action of monochromatic radiations.

These facts demonstrate the caution with which we must interpret the action spectres of the light in morphogenesis.

. Sinapis alba.

Mustard was the object of numerous studies in different laboratories. However, photoperiodic reactions (in the strictest sense)were not analyzed and, in this respect, the behavior of Mustard, reputed long day plant, merits being specified.

From the first results, it seems that:

. Even in short day conditions (9 hours of trophic lighting per 24 hours) , the plant finished by flowering after a more or less long cultivation time which depends upon the lighting value.

. The most favorable conditions for floral induction are continuous lighting conditions (strong lighting) ; 1 or 2 long *days* are sufficient.

. Long day conditions classically used in photoperiodism (9 hours of trophic lighting and 15 hours of weak incandescent lighting) are less effective than continuous lighting. With this cultivation rate minimum induction time, at 22°C, is about one week for plants submitted to a long day at a 6 leaf stage.

. The action spectra (in the process of completion) shows that the most effective monochromatic radiations are at 730 nm , for an induction per 7 photoperiodic cycles. With larger number of inductor cycles (14 for example) , the spectrum is enlarged to 660 nm.

The results obtained with other long day plants *(Blitum virgatum* and *Blitum capitatum, Anagallis arvensis)* also provide precious information as to the role of various monochromatic radiations in terms of time :

-with *Anagallis arvensis* continuous lighting exerts several consecutive effects, integrated by the plant, and the observation, on a macroscopic scale, of one lone physiological criteria (here, floral expression), to measure the effect of lighting, is insufficient to take into account all the phenomena ungeared by light.

. With *Blitum capitatum* and *virgatum* , in contrast to *Anagallis arvensis,* it seems that the total length of lighting is the essential phenomenon and not the moment of lighting during nycthemeris.

Light, and more particularly the use of monochromatic radiations, is then an excellent tool to help in understanding the mechanisms linked to determinism in flowering.

3. Germination of *Chenoeodium20. L22ermon* seeds.

The percentage of germination varies according to the position of the seeds on the plant :

. In LD, the seeds collected in apical position hardly germinate in darkness but light stimulates germination and the percentage of stimulation is all the more important when the seeds are collected closest to the apex: there is an aptitude gradient for germination in the acropectic sense.

. In SD, the results are identical although less clear.

IV. CHRONOPHYSIOLOCY OF METABOLISM PHOTOPERIOD RESPONSE

I. Coordination Mechanism of Intermediary Metabolism.

A. Functional relations between the "CAM way" , the tricarboxylic acids cycle and the amino acid biosynthesis.

Certain connecting aspects between the working of the CAMWay (PEP carboxylase -4- malate, pyruvate) and the working of the tricarboxylic acids cycle or the amino acids biosynthesis, in the leaves of *Kalanchoe blossfeldiana* , under the effect of photoperiod changes were specified.

a) The rythmicity of the tricarboxylic acids cycle appears to be determined by the daily working kinetics of the malic enzyme, intervening as an entrance signal.

b)Relations between amino acids synthesis and the daily working of CAM were considered in a more thorough manner.

It appears that :

-marking experiments based on different substrata always lead to a predominant marking of glutamate, with constant values in the ratio of ^{14}C-glutamate/^{14}C -total amino acids, during 24 hour cycle ;

-in particular, in short days, the maximum CO2, incorporation takes place at the end of the day, quickly becoming darkness, above alt in that which concerns aspartate. This behavior is not in direct keeping either with the variations of the PEP carboxylase capacity or with those of the aspartate aminotransferase (AAT): it can be due either to much use of the aspartate until darkness (which would be in keeping with increasing AAT capacity , but was able to be confirmed by research done to find the products of aspartate transformation), or an actual decline of AAT activity in spite of an increase in capacity.

B. Functional Relations between the CAM way and glycolysis

A study of glycolysis variations, on 24 hour cycles and at different stages of photoperiodic treatment, was conducted by a compared quantity analysis of intermediate metabolitic pools by the so-called "cross-over point"method and made it possible to localize the probable steps of in *vivo* regulation which are phosphofructokinase and the 3-P glyceraldehyde dehydrogenase, of which only the second varies in terms of the photoperiodic regimen.

C. Regulating Role of balances between enzymatic activity at the junction point

CAM is good material for studying the "mystery" of the apparent excess of enzymatic capacity, which we postulate as playing an essential role, and perhaps a very general one, in regulating adaptation mechanisms to variations of external factors.

a) Competition between malate dehydrogenase and aspartate aminotransferase

The case of an actual decline in aspartate production at the beginning of the night could be explained according to two non exclusive hypotheses: ordinary competition for oxaloacetate, becoming very favorable to the MDH in spite of the increase of AAT capacity; or else an AAT retroinhibition by a product of aspartic metabolism, being accumulated at night, above all in short days (which is the case in arginine, which would then be a good candidate for the role of inhibitor , because it can in *vivo* inhibit these plants' AAT).

b) A balance between the phenols synthesis and the CAM way both coming from the PEP, was studied starting from the observation that variation kinetics after changing photoperiod are opposed. By the demonstration of the semi-specificity of a flavonoidic fraction in the inhibition of 3 CAM enzymes, results recently have been added which Lend to prove that this inhibitor effect could actually intervene in *vivo* : the incorporation by root way of the precursor of the flavonoids is accompanied by a distinct decline in the development of the CAM process in short days.

D. Effects of SO_2 at subnecrotic doses

A study of the action of SO_2, given at subnecrotic doses in the air during long lengths of time, on enzyme capacity belonging to different processes of intermediate metabolism was observed on Bean.

This work shows some new aspects on the coordinated response process of intermediate metabolism to external perturbations. Moreover, structural changes observed in a parallel manner by electronic microscope suggest that there should be an effort to develop these studies more particularly on the level of the workings of chloroplasts.

E. A comparative study of constituents of affinity of the PEP carboxylase of CAM and C4 plants.

The measurement of Km(PEP) and Ki(malate) of the PEP carboxylase extracted from CAM plants and C4 plants was taken up again. Quantitative analyses were done for *Kalanchoe blosfeldiana, K. fedtchenkoi, K. velutina, Bryophyllum daigremontianum, Sedum spectabilis, Atriplex spongiosa*

II. Photoperiod induction and enzymatic rhythm

A. Forms of the PEP carboxylase

This research aims to determine if the PEP carboxylase of CAM is constituted by different molecular forms according to photoperiod.

B. Role of the phytochrome

Given the similarity between the kinetics of induction (in the photoperiodic sense of the term) of flowering and the kinetics of induction of CAM in *K. Blossfeldiana,* the CAM system appears apt for furnishing a model of action of the phytochrome usefully responding to levels of precision and of specificity required by the considerations indicated above.

*a) The endogenetic rhythm of sensitivity to the signal. coming from the phytochro***me** was specified in the leaves of *K. Blossfeldiana* by quantifying the PEP carboxylase capacity and, in a parallel flowering, under different regimens of long night interruption.

b) Modifications of PEP carboxylase rhythm phase (set up in continuous lighting) at the time of transfert to light red or far red confirming phytochrome intervention on this rhythm, with a response certainly very inferior to 3 hours, therefore suggesting a direct action on the enzyme population already present at the beginning of the experiment.

c) The signal "beginning of day" releases malate aecarboxylation, at the terminal stage of the CAM chain, and assures coupling between CAM and photoperiod. It is hoped to establish if tha phytochrome intervenes or not in this response, and if the response only concerns malic enzyme activity or also its capacity.

As a matter of act, in a model of the regulation of a complex mechanism by photoperiod, it is necessary to establish if the two signals "beginning of day" and "beginning of night" intervene in the transmission and, in this case, if they act on the same, or on two different endogenetic clocks, controlling different levels of the mechanism studied.

d) A generalization of the model established on *K. Blossfeldiana* to other CAM plants is in progress: the results actually deal with *K. Velutina (SD), Sedum spectabilis and S. Telephium (LD) Bryophyllum daigremontianum and B. Tubiflorum (LSD).*

III. Molecular characteristics of enzymatics rhythms

The recommendations which have come out of the work of the Dablem Conference, 1975, which met to deal with the theme "Molecular Bases of Circadian Rhythms" stress the study of molecular properties of the enzymes as able to serve as a basis for rythmicity. The research is done in this way on the **rhythms** of PEP carboxylase.

V. PHARMACOGENESIS

Research is focused on a study of eco-physiological factors which intervene in the regulation of alkaloidic metabolism .

A. Tropanic Alkaloids

1) Datura

The summer of 1975 made it possible to show that the normal growth of plants cultivated in the field, in a Mediterranean climate, is identical to that of plants cultivated up till now in Corsica (SRA of INRA). The average amount in scopolamine, drawn from some 30 samples, is from 4 to 5%.. The samples having been taken at late date (end September 1975), it is expected to ***be able*** to attain a higher amount (6 to 7Z) when the sampling is spread out during the summer of 1976.

A hybrid of two *Datura :* ontrich in scopolamine and the other resistant to cold and with a rapid growth, was obtained. Phytotronic tests make it possible to expect that the hybrid will possess at the same time an interesting amount and a greater vigor.

2) Duboisia myoporoides

They constitute the main study material for the eco-physiological regulation of alkaloid metabolism because these bushes present a double characteristic which makes them particularly interesting.

On the one hand, they contain two alkaloid groups (tropanics, 1 scopolamine, hyoscyamine; nicotinics : nicotine, nor-nicotine) , and on the other hand, they make possible work on populations with two geographic origins (New Caledonia and Australia)with different metabolic characteristics. Neocaledonian plants constantly present a predominance of scopolamine on hyoscyamine while the Australian plants show a variation in the relation of these two alkaloids during ontogenesis. During a "juvenile" phase, scopolamine (alkaloid at the end of the metabolic chain) is the main tropanic alkaloid; after a variable length depending on culture conditions, scopolamine no longer accumulates and it is hyoscyamine which becomes preponderant. This phase ***was*** qualified as "metabolic senescence" by analogy to certain annual *Datura* where it has been shown that the transformation of hyoscyamine into scopolamine (epoxydation) only takes place during the juvenile phase of ontogenesis.

A possibility for "rejuvenation" by means of budding was brought to light on these Australian *Duboisia myoporoides .* The buds sampled from "senescent" plants resulted in new plants, after rooting, whose metabolism is complete and in which scopolamine is the main tropanic alkaloid. Subsequently, the accumulation of scopolamine will cease again.

Another interesting result, concerning alkaloid metabolism regulation was obtanied on *Duboisia myoporoides ,* but with the Neocaledonian plants: a disjonction of the metabolism of the two groups of alkaloids at the time of the young plants' regeneration based on calluses obtained in aseptic culture.

The actual results on this subject can be summarized schematically in this way:

-indifferentiated calluses (obtained from stem fragments) contain no alkaloid.
-leaves formed on these calluses are also without alkaloids.
-after appearance of roots, these leaves contain nicotinic alkaloids, in normal quantities, but on the other hand, tropanic alkaloids are always absent, the roots containing at times tropanol (amino-alcohol constituent of hyoscyamine).
-these young plants thus regenerated, kept 2 to 3 months in aseptic culture (with mineral feeding) showed a persistence of the disjunction of two metabolism : a presence of nicotine and of nor-nicotine, an absence of tropanic alkaloids.
-after regeneration of the two categories of organs, transplantation of the young plant in usual culture conditions in greenhouses leads to the complete restoration of alkaloid metabolism with the usual constant predominance of scopolamine over hyoscyamine, characteristic of the Neocaledonian population.

B. P4paver bracteatum

High hopes are held out for this species which is characterized by its amount of theban, non-stupefying alkaloid, industrially transformed into codein, a widely used alkaloid.

The acquired results made it possible to know certain physiological requirements : the plant has an absolute need for vernalization in order to give rise to flowering and to capsule production, the organs which are richest in alkaloids. Vegetative multiplication, by fragments of stock, was realized. It allowed for the constitution of clones with a high amount of theban.

C. Cannabis sativa

The problem which must be resolved, with the aid of the Phytotron, is to determine the reciprocal importance of genetic factors and climatic conditions in the plant's elaboration of psychotropic polyphenols. For several generations.

Starting with seeds furnished by the Narcotics Laboratory in Gevena, three generations of plants have been obtained in two climatic conditions (32-12°C and 22-12°C). The great genetic heterogenity of the seeds furnished, has revealed two the - mical "races", within psychotropic polyphenol plant groups: an active molecule able to have a lateral chain, in C3 in C5. The quantitative results also being very heterogeneous , work is now being conducted from clones obtained by propagation of plants by cutting belonging to the two chemical "races".

VI. ECOPHYSIOLOGY

A. The ecophysiology of primary production

The action of the factor of light on elements of the production balance (photosynthesis, respiration).

An analysis of the relationship between plant growth and development and the function of the corresponding primary production by studying the terms of the net productivity balance of a L. D. Plantplaced in a controlled condition of day length or total energy received. Mustard *(Sinapie alba)* studied at given stage of development (flowered in long days, vegetative in short days) seems to suggest an eventual relationship with the floral stage.

With *Chenopodium polyspermum* a global increase of nocturnal CO_2 losses, due to the appearance of rising respiration at the end of the night, is very clearly seen, in 9 hour lighting conditions. This does not exist in long day photoperiodic conditions.

Looking for the causes for this respiratory rise made it possible to reveal an endogenous rhythm of respiration in the dark in the entire plant; as with isolated leaves floating on water, induced by the short day conditions. Determining the features of this rhythm and its eventual relationships with stomatic movements is being attempted.

As for *Sinapis* atba, preliminary results seem to indicate that a respiratory rise at the end of the night exists as well in short days as in long days. A specific analysis of the growth of Mustard under these two conditions (foliar surface evolution NAR, speed of relative growths, etc) is in progress. Thus, it is hoped that the relationships that exist between photosynthesis and respiration can be specified in due time in Mustard, and so done under two conditions of growth and different morphogeneses.

B. Hydric factors, growth and morphogenesis of the root system

A study of the interaction of hydric factors of the environment on the growth and morphogenesis of the root system in relation to a water economy in the plant.

During drying cycles, the evolution of the amount of starch and soluble carbohydrates in *Sinapis alba* in relation to the variations in the hydric state of plants was followed.

a)During aging, there is no variation in the hydric state of the sample plants regularly watered: the hydric and osmotic potentials stay constant during the 40 days of culture.

b)The amount of starch and soluble sugars is also unchanged during the biological cycle of the plant. In particular, flowering does not appear to be accompanied by any modification in the amount of carbohydrates of the different organs of the sample plants.

c) on the contrary, in the dryied plants, there is a decrease of hydric potential which produces hydrolysis of the starch in the leaves and in the roots, accompanied by a correlative increase in glucose. Fructose and saccharose remain unchanged. We are attempting, then, to determine what, in the decrease of hydric potential during drying, is due to dehydration on the one hand and, on the other hand, to *increase* of osmotic pressure under the effect of the increase of glucose.

C. Photosynthetic balance and thermic conditions

An analysis of the relationship between apparent photosynthesis and the temperature in *Sinapis alba L.* plants, cultivated at 12°C or at 27°C and a study of the qualitative and quantitative importance of photorespiration.

a)Thermic optima of assimilation, measured for varied concentrations of CO_2in the air, were attributed for two chosen culture conditions:

. At a particular photosynthetic metabolism, realized in each thermic condition;
. At varying stomatic openings in terms of changes of temperature, producing a variation of the CO2 concentration at the level of intercellular spaces.

b) An analysis of the effects produced on apparent photosynthesis by a temporary inhibition of photorespiration, taking place in air without CO_2 indicates that it provokes a strong inhibition of apparent photosynthesis measured in 17 or 21% of CO_2. It produces also a modification of the Warburg effect which becomes analogous to that which one observes in Crassulacea photorespiration which takes place in air without CO2 has at least a function in the photosynthetic apparatus.

The effect produced by the inhibition of photorespiration persists at least two hours after the end of treatment; it varies with the CO_2 concentration at the moment it takes place.

D. Resistance to dryness

1. Influence of photoperiod on resistance to dryness

The results obtanied on *Carex* show the importance of the photoperiod on resistance to dryness.

In conditions of determined lighting (9 hr, 16 hr, 24 hr, 9 hr + 7 , 9 hr + 15), at the same temperature and the same hygrometric degree, the aptitude to support drying and correlatively, the degree of transpiration were studied.

The differences in the speeds of transpiration appear very rapidly, according to the photoperiods. Morphological modifications, bearing in particular on the number of stomates, a number which is much higher under 24 hours of lighting than under 16 hours and above all much higher than under 9 hours.

To reduce the effects of morphologic modifications, we place the plants first in only one condition (e. G.16 hours) and we divide them up between the various photoperiods (9 hr, 16 hr, 24 hr, 9 hr + 7 , 9 hr + 15) ; the variations observed up till now (transpiration) rapidly intervene, while the morphologic modifications did not yet have time to become established; in consequence, the differences obtained can attributed solely to the photoperiod.

II-Morphologic and biochemical (carbohydrates) modifications in the root system water deprivation and during the resumption of growth in *Carex setifolia.*

Depending upon the culture conditions and the nature of the substratum, two sorts of roots, differing in size, are formed from the rhizome in *Carex setifolia*
regularly watered. Under the effect of drying provoking an increase in hydric deficit, root growth is stopped, the extremity is necrosed and a stimulation of the rhizogenesis in the lateral roots is observed.

Roots with a large diameter show, when growth begins again, a tuberous zone just behind the apex. The tuberisation is fugascious and is reabsorbed 48 hours after the beginning of watering, giving birth to one or two fascicular roots.

A comparative histological study of normal roots and tuberisations show that the difference is found at the level of the cortical parenchyma : lacunose in a normal root, it is dense in the tuberous portion, and formed of radial lines of cells which appear to come from an extra-endodermic generating zone. This generating zone exists, moreover, in a state of non-functional shape in normal roots of *Carex setifolia.* An important accumulation of starch in the tuberous roots, in addition, are noted.

Amounts of soluble sugars: saccharose, glucose and fructose increase during drying and pass by a maximum, later for saccharose than for glucose and fructose. A slight increase of glucose and fructose appears from the first days of water deprivation, then there is a decrease; much more important increase of saccharose which also passes by a maximum; which maintains a high osmotic pressure and, consequently, favorized resistance to dryness.

At the time of the renewal of growth, amounts of glucose and particularly saccharose decrease, in the underground parts as well as the aerial parts. The amount of fructose increases in the rhizome. It is believed that the saccharose liberates, by hydrolysis, glucose and fructose. The fructose is accumulated while the glucose is no doubt immediately reutilized.

As for starch, the rhizome, in a normal period, contains a large quantity of it. During water deprivation, this starch is hydrolysed. Starch is accumulated in the roots parallel to the stimulation of rhizogenesis. If water deprivation is pushed to the limit of resistance, a decrease in the amount of starch in the entire plant occurs.

At the time when a renewal of growth is possible, and when the plant is rehydrated, the rhizome reconstitutes his reserve of starch. There is also an increase of starch in the roots during first 24 hours, that is to say precisely during the formation of tuberous roots. This is what the quantitative analyses done in these tuberisations show, as well as corresponding cytologic observations. Then, after regression, starch decreases in the roots.

The increase of starch would be a sign, therefore, of cellular activity not only in the rhizome which is the formation site of new roots and of new leaf sprouting, but also in the roots and especially in the tuberous roots which present meristematic activity and which, by reasorbtion , give birth to roots which are sometimes fascicular.

In comparing this not very resistant *Carex setifolia* and *Carex pachystylis* which is much more so, the amount of saccharose in the latter stays high during drying this higher resistance can be explained by the maintenance of a high osmotic pressure.

In the same way, if resistance to dryness in *Carex setifolia* is increased by exogenous actions of praline or of glutamic acid, the amount of saccharose remains high for a longer time.

III. As regards *nitrogenous metabolism* , we are trying to define the role of praline in resistance to dryness, with the aid of I^4C proline. We furnished, by way of the roots, marked proline to *Carex setifolia* regularly watered: after 20 minutes of contact with the marked element, we find radioactivity in the fraction containing free amino acids, in the one corresponding to proteins and in the one with organic acids. The percentage of marked carbon incorporated increases afterwards with time in these different fractions.

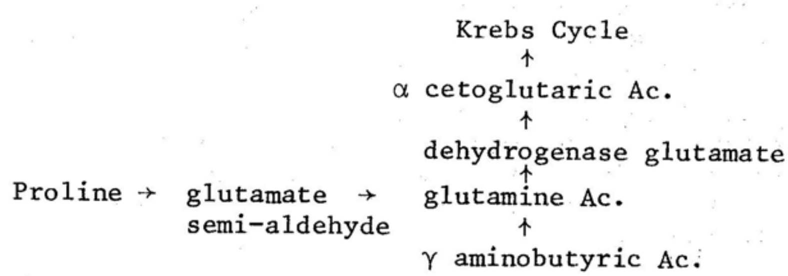
The main free amino acids that are marked are: proline, glutamic acid and *y* aminobutyric acid.

For the protein fraction, only the praline is marked.

As regards organic acids, from the first 20 minutes, the a cetoglutaric acid begins being marked. A little later, all organic acids of the Krebs cycle are marked , in particular fumaric, malic, citric, isocitric acid.

Glycolic acid seems to be the main substratum of photorespiration and the synthesis of this acid is probably the most important factor controlling photorespiration.

The actual results lead us to a first model which is the following :



Proline seems to act as a regulating system with retroinhibition of dehydrogenase glutamate. Therefore, it is necessary to make a parallel study of the action of proline, that of dehydrogenase glutamate.

Research on Gossypium

We attempted to see in strictly phytotronic conditions if the model for *Gossypium* was comparable to that of *Carex.* We used two species : *Gossypium htrsutum* var. B. J. A. , not very resistant, and *Gossypium anomalum* , more resistant; the first one being comparable to *Carex setifolia* and the second to *Carex pachystyZis.*

The evolution of the amino acids and the sugars of *Gossypium hirsutum* were followed at 27°C, 70% *HR,* 16 hours of lighting and at 27°C, 50% HR, 16 hrs. Proline is accumulated as well as asparagines and gamma amino-butyric acid, while glutamic acid decreases. At 50% atmospheric humidity, we find in G. hirsutum a maximum accumulation of these substances, as in the case of Carex setifolia. The Gossypium hirsute model, therefore, corresponds to that of Carex setifolia.

E. Regulation of oxydative degradation of purines by lighting

1. A comparison of C_3 plants and C plants

For *Pharbitis nil, Soja hispida, Nicotiana tabacum, Sinapis alba* puric catabolism is clearly stimulated by darkness: Tests done with Maize, Millet, showed that degradation of purines is the same in darkness and in light.

2. Inhibition of puric catabolism by glyoxylic acid

In vivo , it appears when the cotyledonary discs are immerged in a 10^{-2} M glyoxylic acid.

3. Stimulation of puric catabolism in a oxygen impoverished atmosphere

In air with 1% of O_2 degradation of hypoxanthine is increased by 40% in relation to that of leaves placed in normal air.

4. Stimulation of puric catabolism in a CO_2 enriched atmosphere

In air with 1200 vpm of CO2 degradation of hypoxanthine is twice as strong as in normal air.

VII. MINERAL NUTRITION

A Phytotron makes it possible to work not only on entire plants (cultivation and experimentation in rigorously controlled conditions, reproducible and close to optimum) but also it allows for the possibility of appraising the action of environmental factors (light and temperature) on the phenomena studied. From this comes studies on relationships between root absorption , gradual development of ions absorbed in the entire plant organism and its behavior in regard to the environment, which does not exclude research at the tissue or cell level to confirm and specify the hypotheses set forth.

I. Absorption and migration of calcium in calcicole and calcifuge plants

This work on the organs of entire plants as a whole provide an indispensable element for integrated research which are currently consecrated to calcicole and calcifuge plants. These deal, in fact, for the most part, on roots only, excised or not, or on organites (chloroplasts).

The plant material chosen is that which has been studied the most : Horse Bean and Yellow Lupin. A precaution was taken to associate Yellow Lupin with it so as to be assured that the differences revealed are not only of generic characters.

The results obtained clearly show that up to and including a concentration in a 100 $mEq.1^{-1}$ an the medium Yellow Lupin, calcifuge, is not distinguished by a greater absorption of calcium. On the other hand, the internal repartition of the absorbed ions is completely different from what it is in two other plants: the stem of the Yellow Lupin retains a large part of the absorbed calcium which , in White Lupin and in Horse Bean is accumulated above all in the leaves. The stem of the Yellow Lupin of fers, therefore, privileged sites as a whole for the fixation of calcium (and not of all cations). It has been shown that these sites were above all localized at the cortical parenchyme level and that it was not a matter of retention in the form of insoluble salts.

In these experiments, the roots of Yellow Lupin do not hold more calcium than those of White Lupin or Horse Bean, contrary to what is observed- in the same concentrations- in roots cultivated in *vitro* or in those of etiolated plants. This could be explained by the rapidity and importance of the ascendent transport in our experimental conditions.

The behavior differences in regard to calcium in the calcifuge plant and in the calcicole plant is not merely quantitative. It is above all qualitative: the fixation, the compartmentation of calcium appears different, not only at the root level but at that of the stem.

Thus it is suggested that these differences can play a role even independently of their repercussion on absorption.

II. Ascendent transport of cations and periodicity of sap flux

Transport for a long distance of mineral substances in the entire plant depends in large measure, but not exclusively, on the sap flow. In delicate research on the relationships between these two functions, a study of rhythms can provide a new approach.

It *was* undertaken on "Red Currant" Tomato.

The exsudat is gathered, after decapitation, above the first two leaves, maintained in place. Groups of different plants are decapitated every two hours. These are intact plants, therefore, that perceive the imposed conditions.

The concentration of potassium, calcium and magnesium in the exsudat is not noted for the various output values . An interpretation of the registered values as a whole, up till now indicate that the equation of the representative curve would be that of an equilateral hyperbole. In other words, the same output variation does not have the same repercussion on the concentration for all the values of the former.

The quantities of transported elements towards the aerial parts are determined by output values and values of the concentration. If the cations flow and sap flow is marked in co-ordinates on the same graph, a nearly straight line is obtained. The relationship between these two is then closely connected. Nevertheless, the straight line does not pass through the origin. Therefore, there is not proportionnality between sap flow and potassium flow.

The ordinate at origin is never zero. It is nearly always negative, which would convey the intervention of a reserve compartment in the roots, effecting a sampling in the course of the passage of the absorbed cations towards the sap. The ordinate at origin is positive, in the case of potassium, in darkness, a particular condition where root activity diminishes and where the penetration of potassium is found to be lowered; the intervention of the reserve compartment would become positive in allowing the potassium previously absorbed to accede to the sap current.

III. An aspect of the phosphorus-calcium interaction:retention of both elements at the root level in the case of heavy concentrations in the medium

A study of the effects of temperature and of phosphorus concentration on growth and mineral absorption of Tobacco revealed a phosphorus-calcium interaction which is manifested when both elements are present, both at a high concentration and with the temperature sufficiently high. It is conveyed essentially by a considerable increase in the amount of phosphorus and calcium in the roots.

In sample roots, the largest part of the calcium present in a given mass of fresh matter is found again at the level of the final supernatant (30%) and, above all, of the pecto-celluose walls (58%) whose ponderal importance is considerable; if the results are expressed with regard to a given weight of isolated membranes, on the other hand, the extreme wealth in calcium of the plasmalemme and of the mitochondrial membranes (amount of calcium 7 to 8 times superior to that of the walls, 4 times to that of the microsomes) appears.

When a calcium supplement is accumulated in the presence of a heavy concentration of PO_4H_2 in the medium , the amount of calcium increases in all the fractions, except the supernatant. The largest amount of increase (x 4, 6) is observed at the level of the Plasmalemme.

IV. Action of a relatively low temperature (12°C) applied at the root level on the absorption and the migration of phosphorus and of cations

This study was done on an early simple corneous hybrid of Maize, parallel to that of growth and development. In disassociating the action of low temperatures at the root level to that exercised at the level of the aerial part, it produces a physiological contribution to an understanding of their effects on the growth of Maize at an early stage, which is an important agronomical problem north of the Loire (France).

12-12°C. Three treatments were compared : 22°C (aerial parts) - 22°C (roots) ; 22-I2°C;

It appears clearly that the temperature of the root medium is determinant for absorption and that a temperature of 12°C at this level reduces it considerably. This reduction does not appear to be the main factor limiting growth in these conditions. In consequence, an amelioration of fertilizers at this stage can hardly be hoped for.

- o -

Editors'Note. Readers who would like to have more detailed information about these research should contact the authors directly. For this purpose we give below a list of work in progress.

WORK IN PROGRESS AT THE PHYTOTRON AT GIF-SUR -YVETTE

I. The Physiology of Flowering

1-Compared physiology of the flowering processes:

- -Action of cool and cold temperatures at various stages of development of Maize (Mr. Blondon)
- -Optimal conditions and minimal temperatures for Pepper culture (Mr. Blondon)
- -Role of the phytochrome in sequences of floral induction in *Bryophyllum* (Mr. Blondon)
- -Influence of roots and their conditioning on floral induction in *Perilla* (Miss Deronne)
- -A study of the Poplar growth (Miss Deronne)

2. Flowering in *Anagallis arvensis :* photoperiodic effect and influence of internal factors :

- -Culture of meristems in *Anagallis* (Miss Fontaine)
- -Optimal flowering conditions in *Anagallis arvensis* (Mrs Imhoff)
- -Study of senescence in *Anagallis arvensis* (Miss Larrieu)
- -Relationships between induction of flowering and rhizogenesis in *Anagallis arvensis* (Mrs. Bismuth).

3. Photoperiodism in long day plants :

-Role of the phytochrome in elongation and floral induction in *BZitum* (Mrs Jacques)

-Transmission of floral stimula in the *Chenopodium* family (Mrs Jacques)

-Growth and development of various species of long day *Calamintha* (Mrs. Jacques)

4. Development and correlations between organs :

-Influence of roots on the growth and development of plants photoperiodically exigeant (Mr. Miginiac, Mr. Blondon and Miss Deronne)

-Action of cytokinines inhibitory for flowering (Mr. Miginiac and Miss Fontaine)

-Physiology of flowering (Mrs Brulfert and Miss Fontaine) 5.

Flowering and correlations in *Artemisia herba-alba* (Miss Pourrat)

II. Directed Morphogenesis

-Influence of the physiological state of the mother plant before explant excision (Mrs. Nguyen Thi Dien)

-Influence of environmental conditions of culture tubes (Mrs Tran Thanh Van)

-Determination of environmental conditions of explant (Mrs Tran Thanh Vnn)

-Substrata-explant exchanges (Mrs Tran Thanh Van)

-Morphogenesis and flowering in *Torenia* (Mr. Chlyah)

-Morphogenesis late flowering plants: *Phalaenopsis, Geum* and *Cymbidiwn* (Mr. Marcotte and Mrs Tran Thanh Van).

III. Phytochrome and photophysiology

-Action of light, via the phytochrome on stem elongation and floral induction (Mr. Jacques and Mr. Lecharny)

-Role of the phytochrome in floral induction by light in *sinapi:s , z, b* (Mr. Allot)

-Action of light on seed of *Chenopodium polyspermum* (Mr. Ambrosi)

-Action of light and of the phytochrome on floral induction in *Calamintha* (Miss Tcha)

IV. Chronophysiology of metabolism-Response to the photoperiod

-Activity of malic enz. in *KaZanchoe blossfZdiana* and activity of light on the malic enzyme (Mrs. Morel).

-Plants with CAM and inductive scheme for photoperiod (Mrs. Brulfert)

-Action of photoperiodism on the enzymes of carbon metabolism (glycolyse) (Mr. Queiroz and Mr. Pierre)

V. Pharmacogenesis

-Influence of climatic factors on the accumulation and the biogenesis of certain secondary metabolites, alkaloids and polyphenals (Mr. Cosson)

-Reciprocal importance of genetic factors and climatic conditions in polyphenol elaboration in *Cannabis sativa* (Miss Boucher)

VI. Ecophysiology

-Action of the light factor on elements of the production balance (photosynthesis , respiration) (Mrs. Mousseau)

-Hydric factors, growth and morphogenesis of the root system (Mrs. Vartaninan) -Photosynthetic balance and thermic conditions (Mr. Cornic)

-Resistance to dryness (Mrs. Hubac)

-Regulation of the oxydative degradation of purines **by** lighting (Mrs. Nguyen)

VII. Mineral nutrition

-Migration of calcium and potassium in the plant (Miss Scheidecker)

-Effects of temperature and concentration on phosphorus in rho growth And mineral nutrition of Tobacco (Mrs Rivid)

-Circadian rhythms of calcium and potassium migration in regard to sap flow in different lighting and temperature conditions (Mr. Monard and Mr. Panissot)

Calcium transport towards and in aerial parts in calcicole and calcifuge plants (Mrs. Bousquet).

- o -

IX. NORTH CAROLINA STATE UNIVERSITY PHYTOTRON ANNUAL REPORT 1975

Director : Dr. R. J. Downs

Editor's Note. We received the 1975 Annual Report from Dr. R. J. Downs, Director of the Phytotron. We have extracted from it the following paragraphs for our readers. Those desiring more information should contact Dr. R. J. Downs, S. E. P. E. L., 2003 Gardner Hall, Raleigh, North Carolina 27607 , U. S. A.

- o -

Introduction. The research that takes place in the phytotrons of the world is obviously not field research, nor can it be classified as "ivory tower" basic research based solely on scientific curiosity. World wide, and this includes the NCSU unit, phytotron research would be considered largely practical basic research; investigation of fundamental biological principles in order to solve an immediate agricultural problem or immediately improve crop production.

The North Carolina State University Phytotron is dedicated to research on the basic influences of environment on primary growth processes of plants. The Phytotron is organized in such a way that combinations of controlled-environment cabinets, rooms and glasshouses can be used to study many factors of the environment simultaneously.

The NCSU Phytotron in conjunction with the Duke University phytotron make up the Southeastern Plant Environment Laboratories (SEPEL) and its therefore a regional laboratory available to any biologist requiring controlled-environment facilities.

Many scientists find they can conduct research programs in the Phytotron while remaining at their home institutions. This is possible because the Phytotron staff handles the daily care of the biological material and part-time assistance can be obtained for periodic treatments and data acquisition. These visiting scientists appear at the Phytotron only at crucial stages of the research program.

Investigators using the Phytotron represent most areas of plant science. Many of the researchers are located at NCSU but an increasing number are from other areas such as Virginia, South Carolina, Georgia etc.

The NCSU Phytotron operation is funded by the N. C. Agricultural Experiment Station and by the National Science Foundation. A Phytotron board consisting of representatives from NCSU and Duke Universities determine the operating policies of SEPEL. These policies must conform to the requirements set up by the funding agencies. Applications for research space in the Phytotron are sent to the Director who presents them to a committee for review and priority rating. The committee members represent several major research areas so that every proposal can have an authoritative review. Thus zoology, entomology and pathology are represented as well as the plant sciences. A regional phytotron committee with members from nine of the southeastern states reviews the overall operation of SEAL including the evaluations of the research proposals made by the local committees.

Procedures for preparation and approval of Phytotron space requests have been changed several times to facilitate the process. We try to keep the time lapse between submittal and approval as small as possible; never greater than one month. To this end we have prepared new application forms that will assist both the prospective investigator and the approval committees.

Details of the procedures and policies are presented in the Procedural Manual for Controlled Environment Research (available on request to R. J. Downs, 2003 Gardner Hall, NCSU). The Manual also provides the investigator with information that will assist in planning his research i. E. Chamber and truck capacities for containers of various sizes, radiant energy , nutrient solution, watering schedules, etc.

THE ANNUAL REPORT

In the past the Phytotron Annual Report was prepared solely by the Director primarily to describe the improvements in the facility and the phytotronics that improved the overall operation. Generally the research was listed by title and investigator. This year, while improvements and phytotronics will still be discussed, more emphasis is on the research. To provide the most authoritative report the researchers have been asked to contribute articles about their research program.

General Activities :

The public , lay and scientific, continue to show great interest in the Phytotron and its contributions to biological knowledge. Visitors to the Phytotron in 1975 represented 20 foreign countries and many states of the USA.

The Phytotron was also involved in the 1975 Commercial Flower Growers Meeting, Pest Management Workshop, Pickle Producers Association, and the NSF sponsored program on Biological Tactics in Integrated Pest Management Systems held in cooperation with Republic of China.

Physical Plant :

The Phytotron physical plant is described in BioScience 20: 1201-1208, 1970 and in the Procedural Manual. Three sizes of artificially lighted chambers, temperature-controlled glasshouses, seed germinator cabinets, photoperiod rooms and air pollution treatment roomettes provide a wide choice of environmental conditions.

A and B chambers : The Phytotron controlled-environment chambers are under continuous modification; not to increase the precision of control which has always been good, but to improve reliability. Fail-safe controls, redesigned sensors, up-graded controls components and most recently increased alarm sensitivity have advanced our systems to the point where no research has been lost to electrical or mechanical failure for several years. This does not mean that malfunctions do not occur but rather that the off-normal conditions are of such brief duration and/or small magnitude that the investigators have not considered the error to be significant. The vastly improved preventive maintenance program instituted in the latter part of the year *is expected* to reduce malfunctions even further.

C-chambers: Each of these units operates on its own direct-expansion refrigeration system, which unfortunately are at the end of their effective life. We can recognize failure symptoms before a substantial temperature shift occurs: whereupon the research material must be shifted to another chamber. This means that one or two units must operate on a standby basis, reducing our number of effective chambers. In the next few months we expect to complete the test necessary for converting the C-chambers to the secondary coolant, centralized refrigeration system and thereby return to operation our full complement of units.

Glasshouses: Control of temperature in the glasshouses has been very good for this type of structure. However we noted a tendency for the temperature to drift from the set point; usually upwards, and often as much as 2°C. An analysis correlated the drift to intermittent cloud cover. The control system was then redesigned to use three sensors with appropriately shared authority and we believe the drift problem has been eliminated.

Seed Germinators : While these units function quite well, cleagines problems arise from the use of building chilled water for temperature control. Alterations currently in progress will use deionized chilled water and allow lower germinator temperature of 5°C.

NEW FACILITIES

Automatic Watering : Application of water and nutrient solution by hand at best limits overall flexibility and at worst can cause cultural problems by altering ion up-take ability or allowing salt accumulation in the substrate. Automatic watering systems are being installed and will soon be available to all units. Programmed schedules of water and/or nutrient solution are being developed which will allow a wide sehttion of frequencies and rates. The system is designed to allow continuation of the practice of moving trucks from one environment to another.

Photoperiod Rooms : Six temperature-controlled photoperioirooms will be operable before the end of the year. Temperatures can be selected over a range of 10 to 35°C and any photoperiods can be obtained using incandescent and/or fluorescent light sources. Farred sources, such as BCJ lamps , can also be used and the fluorescent lamps can be filtered to provide red light sources of good purity. The programmer will provide any sequence of the two sources with on times of a few seconds per minute to continuous. Materials have been obtained for three additional, and somewhat larger, photoperiod rooms which will become operational in 3 or 4 months.

Air Pollution Research Laboratory : An area of the Phytotron was developed for air pollution research. This laboratory contains four temperature and humidity-controlled, gas tight, treatment roomettes; each lighted with metal halide, high intensity discharge lamps. The treatment roomettes are an improved desing that allows rapid and uniform dispersion of injected gases throughout the chamber air volume. Control levels as low as 1 ppm (1 part per hundred million of ozone) can be obtained and several gases can be mixed to provide a wide range of atmospheres. Monitors are available of course for the major gases of interest e. G. ozone, sulfur dioxide, nitrous oxide, carbon monoxide and carbon dioxide, etc. Other phytotoxic gases can be studied also and
experienced personnel are available for consultation in developing air pollution research programs.

Space Utilization: The occupancy at the NCSU Phytotron is shown below.

	Percent Occupancy by	
A-chambers	Space	Time
Adjustable program		85
Fixed program	74	100
B-chambers		83
C-chambers		84
Glasshouses	40	100

When the entire chamber is assigned to an investigator we assume he fills it.

A new computer program was developed for improved inventory control and to present occupancy data in various categories such as source of funds, crop and field of research.

Approval procedures for phytotron space requests allowed for comprehensive review while holding lead time to no more than one month. About 60% of the proposals were approved at the first hearing ; approximately 10% of the investigators were asked to supply additional information; about 30% were returned for revision and resubmittal.

THEMES OF RESEARCH

We give below only titles of research in each scientific discipline. All published papers are quoted under the heading "Articles in print" of this issue.

1) Agricultural engineering.

Mohan Gawande and W. H. Johnson. -Study of the Factors affecting uniformity of Tobacco Seedling Development :

I. The effect of seed size and pelletting process on germination characteristics of tobacco seeds at various day/night temperatures.

II. The effect of seed size and pelletting process on emergence and uniformity of early growth of tobacco seedlings under various day/night temperatures.

III. The effect of environmental CO_2 concentration on emergence and early growth of tobacco plants.

IV. The effect of seed spacing on uniformity and style of plant growth.

2) Air pollution research

W. W. Heck and J. A. Dunning

l. Determined the effects and interactions of growth and exposure temperature, potassium nutrition and ozone dose on the foliar response of bean (cv Pinto) and Soybean (cv Dare).

2. Determined the effects of daylength on the response of 2 soybean as to ozone.

3. Determined the environmental pre-conditioning time period required to change plant response.

4. Soybean plants grown under controlled conditions were subjected to single or multiple acute ozone exposures and rates of change and recovery for a variety of metabolic constituents were determined.

5. The effects of single or multiple acute ozone exposures on growth rates of radish grown under several temperature regimes.

b. The effects of single or multiple acute ozone exposures on growth rates and recovery of Ladino clover.

7. The effects of single or multiple acute or chronic sulfur dioxide exposures and recovery of Carolee oat.

8. The effects of single or multiple acute or chronic ozone exposures on the pathogenicity of several obligate pathogens.

M. B. Letchworth

-The effects of ozone on the growth and quality of Ladino clovers *(Trifblium repens L.)*

U. Blum and D. T. Tingey

-A study of the potential ways by which ozone could reduce root growth and nodulation of soybeans.

C. E. Anderson, R. Lower, and J. Dunning

The effect of photoperiod on sexuality and sensitivity to ozone in a new cucumber variety.

R. A. Reinert, R. A. Larson and V. Bonaminio.

The influence of low growing temperatures on the sensitivity of bedding plants to ozone and the carry over effects under field growing conditions.

D. N. Ross

Response of *Chrysanthemum* to chronic exposure to ozone and suppressant of physiological and visual injury.

D. N. Ross

Evaluation of SADH as a suppressant of ozone injury in *Chrysanthemums.*

3) Environment and plant breeding

D. A. Emergy and J.0 Wynne

Peanut research. Utilization in variety development.

T. J. Mann

Phytotron studies with Tobacco Seedlings:
-Yellow green classification
-Temperature influence on cytoplasmic trait
-Temperature sensitivity classification

D. L. Thompson, and K. Leonard

Resistance of corn genotypes to anthracnose

D. L. Thompson

Seed increase of Gaspe Flint corn

W. R. Henderson and S. J. Jenkins

The mode of inheritance of bacterial wilt resistance in tomatoes.

4)Horticulture

R. D. Wright

1)Effects of temperature and photoperiod on the growth of *Ilex cornuta cv. Burfordii.*

2)Effects of temperature and photoperiond on inflorescence development and fruit set in *Ilex cornuta cv Burfordii.*

H. A. Mendoza and F. L. Haynes

-Variability of Photoperiodic reaction in Potato clones from three taxonomic Groups.

-Inheritance of tubes initiation as influenced by photoperiod in the autotetraploid potato *Solanum tuberosum L.* Groups tuberosum and audigena.

L. H. Aung

-Short day vernalization and devernalization on growth and reproduction of tomatoes

-Interacting effects of photoperiods and temperatures on vegetative and reproductive responses of tomato.

F. H. Oelschig and R. A. Larson

The use preplanting treatments in the forcing of *Caladium bicolor.* J.

J. Rodrigues and D. M. Pharr

Effects of storage, temperature and daylength on development of three Brazilian garlic cultivars.

F. L. Haynes

Identification of diploid species of tuber bearing Solanum for heat tolerance. W.

C. Porter and D. C. Sanders

Growth of one low and one high response green bean variety to N under different temperature regimes

D. M. Pharr

Effect of light intensity on the amount of C_2H_4 produced by germinating cucumber seeds.

J. W. Love

Critical daylengths for flower bud initiation of several new Swiss Kalanchoe varieties.

D. C. Sanders and K. Hube

Effect of photoperiod on sex expression in pumpkin.

V. P. Bonaminio

Effectiveness of A-rest (a cyclopropyl - a(4 methoxyphenyl)-5 pyrimidinmethanol) in retarding height of Easter lilies growing in three media at three different temperatures.

V. P. Bonaminio

Feasibility of automatic watering for plants growing in controlled environment rooms.

A. J. Pertuit

Influence of temperature during long night exposures on growth and flowering of 3 varieties of Kalanchoe.

R. A. Larson

Effects of temperature on chemical disbudding of *Chrysanthemum morifolium.* V.

P. Bonaminio

Effect of temperature on bract development and color of Poinsettias.

5)Pathology

E. G. Kuhlman

Fusiform rust in Pine

N. W. Schaad and D.

Sumner

Effects of temperature and light on the infection and pathogenicity of *Pseudomonas avenae* , the causal agent of bacterial blight of oats and corn.

C. E. Main and M. Brant

Feasibility of simulating a polycyclic epidemic of *Alternaria aZternata* on flue-cured tobacco.

T. Vrain and K. R. Barker

Interactions of temperature, moisture and soil type on the infectivity of two species of root knot nematodes.

T. Vrain and K. R. Barker

Effects of low temperatures on infectivity, development and reproduction of root knot nematodes on clover and mustard.

6)Mathematical modeling M. C.

Wann, C. D. Raper and H. L . Lucas

Computer simulation of dry matter production for Tobacco.

C. D. Raper, J. F. Thomas and M. Wann

Dynamic model of soybean growth. I. Vegetative growth phase.

C. D. Raper and M. Wann

Dynamic model of tobacco growth. II. Light intensity and duration.

7)Physiology and ecology

B. Duane

Effects of thermoperiod on pineapple

... Temperature effects on growth and growth habit
-Temperature effects on susceptibility to floral induction
-Effects of temperature on carbon assimilation and leaf diffusive resistance to water vapor.

P. J. Vinyard

The relationship of competition, allelopathy and nutrient stress in *Digitaria sanguinalis L.*

J. F. Thomas

Environmental Physiology of *Nicotiana tabacum.*

Apical meristem reactivity to differences in photoperiod and thermoperiod.
-Seedling growth under several nutrient and atmospheric CO_2 regimes. -Differences in progeny of tobacco due to temperature treatments of the mother plant
-Seed germination as affected by mother plant temperature environment of *Nicotiana tabacum.*

.. The effect of photoperiod, temperature and age of plant upon basic physiological and morphological responses in soybeans.
Environmental factors affecting floral initiation and development in tobacco.

H. D. Gross

Programmed vh. Day/Night temperatures and growth of Soybeans.

J. F. Thomas

Quantitative and qualitative responses of soybeans to controlled environments. I. The effect of age of plant and number of short day treatments upon floral and pod development under different temperature regimes.

J. D. Colosi and E. D. Seneca

The effects of thermoperiod and photoperiod during seed maturation on the subsequent rate of germination in *Unioia paniculata* and *Iva imbricata.*

I. Mendolsohn and E. D. Seneca

The effect of salinity and ammonium concentration on the glutamate dehydrogenase activity of the salt marsh grass, *Spartina aternifiara.*

S. Crum and R. P. Patterson

Effects of water stress on burley tobacco.

J. H. Singh and H. D. Gross

Effect of environment on yield and seed quality of soybean

H. D. Gross ,

Environmental control of flowering responses in determinate soybeans. T.
J. Monaco

Effects of low temperatures on the survival on camphorweed.

8)Zoology

H. Underwood

Photoperiodic Time-measurement in the Male Lizard *Anoiis carainensis.* R.
M. Burr

Effect of environmental temperatures on a technique used to determine mean whole blood clotting time of pine vole.

9)Weed control

F. T. Corbin

Influences of temperature on the response of cotton to the herbicide, 3-tetrafluorethoxyphene-N-N-dimethyl urea.

T. J. Sheets

Interaction of temperature, trafluralin and nutrients on corn.

T. J. Monaco

Effect of temperature on alachior injury to different varieties of potatoes.

10)Entomology

J. S. Batcheler and R. E. Stinner

Effect of soil type and moisture on the survival of overwintering *Heliothis zea* pupae.

G. G. Shaw

Nutritional effects of different host plants upon the population dynamics of *Heliothis zea.*

11) Tissue culture J. Hunsperger, R.

A. Larson and R. L. Mott

Cold treatment of flower buds of Nicotiana, Petunia and Salpiglossis prior to the aseptic culture of their anthers for the subsequent production of pollen derived haploid plants.

R. L. Mott

Tissue culture methods for propagation of *Cesneriaceae.*

12)Statistics

Chong Lee

Uniformity of environmental conditions within several types of controlled environment rooms and the determination of proper experimental designs.

13)Germination

J. F. Thomas

Weight and germinability of flue-cured tobacco seeds obtained from field grown mother plants subjected to 3 rates of fertilizer, removal or non-removal of senescent leaves and with 3 or 9 branched inflorescence development.

J. F. Thomas

Seed development of flue-cured tobacco under 3 photoperiods and two thermoperiods.

D. E. Moreland

Bioenergetics of growth and development during early stages of seed germination.

O

X. DUKE UNIVERSITY PHYTOTRON Annual Report 1975

Editor's Note. We have received varied documents from Prof. H. Hellmers, Director of the Duke University Phytotron from which we have extracted the following information for our readers. Those who desire more information should write to the : Prof. H. HellmersDepartment of Botany, Duke University Durham, N. C.27706 USA.

Prof. Hellmers wrote to us :

"Last year in my covering letter with the phytotron Annual Report I asked several questions in regards to the *use* of phytotrons. I received replies and Annual Reports from many phytotron Directors. The general theme, for the most part, fit in quite well with our philosophy and experience. First, research in a phytotron should be done to supplement or compliment field research, not replace it. Second, the problems to be worked upon should originate in the field and not in phytotron per se. Third, unless the phytotron is a part of the national agricultural experiment station, and even then sometimes, it is difficult to get field people to come any distance and use the phytotron.

"It was interesting to hear that some have problems similar to ours and to hear how others have solved the problems. One approach was that of holding a workshop which we recently did for agricultural research personnel. The more than twenty that attended were enthusiastic. Now we will see how many actually use the facility. An added difficulty we have in convincing researchers to use the facility is that all users have to pay for it out of their own research budget. Consequently, we have increased our efforts to make the research community aware of the phytotron, its capabilities and advantages economically through workshops, newsletters and brochures.'

"Ian Wardlaw of the CSIRO Phytotron in Canberra Australia raised the question of what units to use in reporting light units in publications. The measurement and reporting of light energy has been a problem over the years. With the meters now available I would agree with the request of the Australian Journal of Plant Physiology to Ian that quantum flux be measured and reported in microeinsteins per m^{-2} sec^{-1} (in the range of 400-700 nm) for photosynthetic active radiation or if radiant energy is needed use watts m^{-2} over the same range. This has problems related to the far red energy. However, I believe it would be a great improvement over foot-candles or lux measured with a photometer which is specifically designed to read in the green band.

"As described in the report we are installing a CO_2 monitoring and control system and an automatic water system. Also, an electronic control system is being developed to increase our flexibility in controlling temperature and lighting programs in the chambers:'

*Ian Warrington, Director of the New Zealand Controlled Environmental Laboratory, spent the past six months here. We profited a lot and he was able to get some research done without having administrative duties consuming his time. We hope to do some joint experiments in the future , not only to learn more about plant growth, but also to compare plant growth characteristics in the two facilities... P

ANNUAL REPORT 1975

Introduction

The Duke University Phytotron consists of forty controlled environment chambers and six controlled environment greenhouses all on one floor. The plants are grown on carts and the daily moving of carts from one condition to another is a routine procedure so that the environmental complex of available conditions becomes almost limitless. Thus, the Phytotron provides facilities that make it possible to conduct experiments that cannot be done anyplace else in the country. Also, experiments that would require years using one or two chambers can be completed in terms of weeks in the Phytotron.

The entire building, the equipment and its operation with back-up systems was designed to provide accurately controlled and reliable plant growth conditions. Consequently, our loss of experiments due to equipment failure or human error is extremely low. This year a CO_2 monitoring and control system for the chambers and greenhousA4 is being installed. In addition, an automatic watering system is available and is recommended especially for larger plants.

The Phytotrons are service facilities and not institutes. Therefore, the facilities are available to serve biological scientists over a wide spectrum of disciplines including ecologists, plant physiologists, geneticists, pathologists, entomorphologists, plant biochemists, plant taxonomists and plant anatomists. By not being an institute the Phytotron does not have a dominating internal program or scientist that dictates usage. Rather, application for space for each experiment is judged on its own merit rather than how it fits a preconceived institute or agency program.

The Regional Phytotron Review Committee of thirteen members from universities, government agencies and industry was established in 1975. Dr. James Henderson of Tuskegee is Chairman of the Committee . The Committee is responsible for guiding the development and use of SEPEL as a regional and national resource and for reviewing priorities assigned to projects submitted for use of the facilities. In addition, a technical review board of six members and an external review system has been formed to screen all projects and to assign them priorities.

Utilization

During 1975 the Duke University Phytotron was used by forty-seven scientists. One came from New Zealand on a fellowship and another on his sabbatical from New Mexico. Others from shorter distances commuted to the laboratory at crucial points in their experiments. Staff and graduate students here at Duke University also used the facilities quite extensively, as would be expected. Because the Phytotron staff does all the routine work in the care of the plants, scientists from as far away as Illinois, Mississippi and Georgia have found the use of the facility not only to be a rapid way to do experiments but also an economical operation even when commuting costs are included.

This past year special efforts were made to acquaint more off-campus people with the capabilities and availability of the Phytotron for their research and thus to increase the regional and national *use* of the facilities.

Space utilization has continued at a relatively high rate but because of the day/night placement of trucks in different conditions it is very difficult to determine space occupancy percentages. In addition, the two types of large controlled environment chambers and greenhouses require aisle space in order to care for and work with the plants. Nevertheless, based on the number of trucks available plus the area of the reach-in chambers it is calculated that space utilization during the year averaged 97 per cent. This figure is a little high for actual usage because *when* a researcher requires an entire unit he is charged for it as a unit rather than on the actual space used to grow his material. The per cent usage remains fairly constant, however, varying between 92 and 98 per cent for the past four years.

There are several obvious advantages that accrue to the scientist who uses the Phytotron.

l. Experiments can be started on short notice, usually less than one month.

2. A wide range of controlled environments can be obtained simultaneously. For example, several experiments have used up to 30 combinations of day/night temperatures and photoperiods.

3. Time to conduct a multi-environment experiment is kept to a minimum thus reducing variability due to the passing of time.

4, The past record of reliability for the Phytotron equipment shows that the chances are very high that an experiment will be completed without loss of plants due to mechanical failure.

5. The scientist -

a) does not need to raise money for a capital investment.
b) does not need to install or learn how to operate the chambers.
c) is not burdened with maintenance problems.
d) does not *need* to be at the Phytotron all the time during the experiment. The Phytotron staff carries out the daily routine care of the plants.
e) will not be left with an expensive piece of equipment after the experiment is completed.

There are, however, specific responsibilities the scientist must assume in order to take advantage of the facilities. One, the space must be rented, so money has to be obtained from a granting agency or some other source. Two, the scientist either has to make several trips to the Phytotron or spend a period of time here depending upon the nature of the experiment. The scientist is responsible for planting, special treatments, measurements and harvesting of the material. In summary, balancing the pros and cons, a scientist using the Phytotron for complex or Wide-range-condition experiments will save considerable time and money over developing and operating their own system.

The availability of space in the laboratory and details on procedures and policies can be obtained by writing to H. Hellmers, Botany Department, Duke University, Durham, N. C.27706. We welcome inquiries and will provide assistance in planning experiments to obtain maximum benefit to the researcher from the equipment and conditions available.

PAST AND PRESENT RESEARCH

During the seven years that the Phytotron has been operating, experiments conducted in the facility have been adding basic and fundamental information to the pool of knowledge on how plants function and grow. Several of these findings in the Duke University and North Carolina State University units have changed and continue to change the basic concepts of those in various sectors of plants research. Examples from the Duke phytotron are given below in the paragraphs on temperature, light, water relations and carbon dioxide concentration effects on plants and show the quality and the wide range of experiments that are conducted in the phytotron. The following examples appear to be major contributions in the various areas of research.

<u>Temperature effects</u> : Plants have repeatedly been found to have optimum temperature requirements for growth that are outside of the temperature range that occurs in the natural distribution of the plant. An example was the discovery that Monterey pine grows fastest under a much cooler night temperature than could have been anticipated from weather records of the Central California coast, (Hellmers and Rook 1973). This provided a clue as to why there is better than anticipated growth of the plants in parts of the world where they are not native. The study involved the use of 30 combinations of day and night temperatures. Had not the capability of the Phytotron to supply this wide range of conditions been available, the fact that a low (5°C) night temperature is so important probably would not have been found. This is a temperature much below what the plant normally encounters in as natural range and would not have been used had the experiment been restricted to half this size. The Phytotron results were later confirmed in field measurements by D. S. Jackson and H. H. Gifford (1974).

Another first was the identifying and proposing the concept of acclimation ecotypes by Billings (1971). This was made possible through a series of experiments in controlled environments using arctic and alpine collections of *Oxyria digyna.*

R. S. Alberte (1974) working with six nuclear mutants of corn, six of soybean and seven of cotton showed that the leaf chlorophyll a/b ratio was correlated with temperature. Thus, temperature was exerting control over the total chlorophyll content and resulting in the differences in size of the photosynthetic unit frequently noted in chlorophyll-deficient mutants.

The Phytotron facilities have also been used to screen cold tolerance of hexaploid and common cultivars of cotton (Muramoto 1971).

A large number of studies were conducted on the relationship of temperature to growth and metabolic processes .

Light effects: J. A. Teeri was able to show for the first time that some plants can respond photoperiodically to changes in light intensity rather thstrequiring a light interruption with total darkness. He worked with plants on Devon Island and observed a distinct flowering pattern in these plants growing under the continuous light of the arctic. Later through his experiments in the Phytotron he was able to show that this response was photoperiodic and not temperature related. Further experimentation demonstrated the necessity for only a change in light from 0.3 ly min^{-} I. to approximately 0.1 ly min^{-1} for six hours to obtain the control of flowering observed in the field.

Others have studied plant growth and dormancy to obtain data on responses to photoperiods and irradiance .

Water relations : A large number of experiments have been conducted on water stress and its affect on growth, drought tolerance and various physioligical processes.

One study dealt on tobacco with the relative effectiveness of vascular connections between adjacent leaves in transporting water. It was found that the diurnal variation in root resistance to water movement could be changed by varying photoperiod on the shoot.

Carbon dioxide concentration : One of the more controversial discoveries from the Phytotron was the delay in flowering caused by a high concentration of CO_2 by Hesketh and Hellmers (1973).

Floral initiation was greatly delayed in four sorghum cultivars and slightly delayed in maize, cotton and sunflower when grown in an atmosphere containing approximately 1.000 ppm CO, es compared to plants grown in ambient air. Prior to this finding, hastened floral initiation in general had been attributed to enhanced production of photosynthate, a theory which was not confirmed by this study. Supporting evidence for the findings in this study have been subsequently reported from laboratories in Denmark and Japan.

Another study using 1.000 ppm CO_2 showed that the growth potential of cotton is not reached in the field with the normal concentration of CO and that the plants can be overloaded with photosynthate if exposed to a high concentration.
2

Multiple environmental interaction studies : The complexity of this type of study involves the use of a wide range of conditions for each of two or more factors. Interaction studies to date have included day-night temperature interactions day-night temperature and photoperiod interactions and temperature-humidity interactions and temperature-$0O_2$ interactions.

The use of a large number of controlled environments is required and is the type of experiment which can only be done in a laboratory such as a Phytotron that has the capability to provide these conditions simultaneously. To do this typ' of experiment in a few units would require years compared to months in the Phytotron.

The design of the experiment can proceed one of two ways : Either the effect of the individual factors is first studied over a wide range and then the interaction experiment is run using the critical range established for each factor. Or, an experiment of significant magnitude is conducted to include a significant number of conditions of each factor plus a significant number of cross-over points to be able to analyze for the interaction.

Present studies include interaction experiments to determine the effect of photoperiod, temperature and light intensity on the diurnal cycles found in CAM plants (C. Black and S. Crew).

In another variation of this type of experiment J. A. Teeri, has recently completed a study on plant phenotypic responses to different patterns of environmental fluctuations using several races of *Potentilla gZandulosa* collected from a variety of contrasting natural environments. He has found that the presence of several sine-wave cycles of within-day variance in the temperature and vapor pressure regime can alter phenotypic responses compared to those obtained in a standard "square wave" chamber regime.

Relationship between chamber, greenhouse and field grown plants: Biologists , are frequently confronted with the fact that field and greenhouse or chamber grown plants are not the same. This leads to the question: How can one justify and transfer controlled environment results to the field? A three year cooperative project using the facilities of both units of SEPEL was started in the fall of 1973 under a RANN grant to Drs. Kramer, Raper, Downs, and Hellmers of the two units of SEPEL. The project is a study of the scientific and economic effectiveness of field research as compared with Phytotron research. One major objective is to make careful measurements of the quantity and quality of plant growth made by plants of several species in field plots and in Phytotrons. This information will be used to answer questions such ***as*** the extent to which results obtained in Phytotron studies can be used by agriculturists, foresters, plant breeders, and ecologists to predict the behaviour of plants in the field. This information also indicates the extent to which information on plant growth obtained in Phytotrons can be used to construct models useful in explaining plant growth in the field.

The second major objective is to make careful comparisons of the cost efficiency of research in Phytotrons as compared with research in field plots. Some research can be done only in field plots, some only in Phytotrons, but many experiments might be done either in the field or in controlled environments. A better understanding of the relative costs of field and Phytotron research will aid administrators and scientibls in determining the most efficient method of achieving particular research objectives.

Other individual but valuable studies : a)Lichens were not only grown successfully in the Phytotron but conditions for very rapid growth were established for several species . Previous attempts to grow lichens in greenhouses throughout the world had invariably met with failure.

b)By the simple modification of installing UV lamps in the air duct of several reach-in chambers the ozone level in the units was controlled for an air pollution study on CO_2 fixation rates in pine.

c)Biologists and especially the biochemists have been slow to recognize the necessity of uniform plant material for reliable and repeatable results. Lt was fine to use grocery store spinach in studies on the gross studies of photosynthetic systems but as the questions asked become more specific and involve variations of chemical-synthesis pathways within a plant there is a need for knowledge of the plant growing conditions. Several researchers have used the Phytotron facilities to obtain uniform and known-condition-grown material.

d)The determination of plant population variability has been the object of several studies.

e)Phenotypic plasticity if various species of *Plantago* and other plants are being studied by Dr. Antonovics and Dr. Billings. In addition to observations on difference in morphology, time to floral initiation and growth rate, research is being conducted on heavy metal toxicity tolerance.

- o -

XI. SOME CHARACTERISTICS OF PHYTOTRON AND GREENHOUSE UNITS AT THE INSTITUTE OF BIOLOGY, UNIVERSITY OF NOVI SAD (Yougoslavie)

Editor's Note. We received from professor M. R. Saric the director of the Phytotron of Novi Sad (Yugoslavia) a mimeographed book :"The use of Phytotrons and greenhouses in dealing with some problems in Phytobiology and the most important technical requirements in Phytotronics" (1975 Ed. Stamparika Univerziteta Novi Sad - 36 pages). From this book we reproduce some informations for our readers. Those who want to receive more details can write to : Prof. M. R. Saric. Institute of Biology. University of Novi Sad . Yugoslavia.

- o -

Research in our Institute during the last ten years was carried out in the direction of growing plants under fully controlled conditions, and special attention has been devoted to the effect of illumination, particularly to its spectral composition. For this purpose climatic chambers-miniphytotrons have been purchased and installed at the Institute of Agricultural Research in Novi Sad; in 1960, a climatic chamber was purchased from Kansas Applied Co., USA, and in 1964, climatic chambers were built by the factory of refrigerator apparatuses at Skofja Loka, Yugoslavia. In 1970, phytotron units produced by Votsch (-F. R. G.) and greenhouses produced by Henssler (F. R. G.) were purchased and put into operation at the Institute of Biology, University of Novi Sad.

The following is a brief survey of the characteristics of the climatic chambers, i. E. The phytotron units at the Institute of Biology in Novi Sad.

The characteristics of chambers with different spectral composition of light are presented in Table 1 . These chambers have a constant temperature of 23-25°C and a relative air humidity of 75%.

The sources of light used in the individual climatic chambers were vacuum tubes with the following desitmotions

1. White ; Cool white Fr 96T12-CW-VN0-233-1, Silvania, USA.
2. Red: F 40 Gold XL, Lifeline, Canada
3. Yellow: F 40 Gold XL, Lifeline, Canada
4. Green: F 65T 12/G Green Preheat, USA
5. Blue: F 65T 12/B Blue Preheat Silvania, USA
6. Violet: F 15T8-BLB Blacklite Blue Silvania, USA
7. Sodium; Philips 570358 S0-X 180W III J9, Holland

Tab.1. Characteristics of spectral composition of light in chambers of the Institute for Biology, University of Novi Sad.

Light spectrum	Wavelenghts of spectrum sum	% of spectrum purity	erg/sec. sq. Cm.	Wavelengths shorter than the start ones: 7	erg/sec cm	Wavelengths longer than the last ones: %	erg/sec sq. Cm	Total energy in gham ber	Energy distribution in chamber with white light
Violet	380-425	95, 2	452	-	-	4,	28	480	1, 610
Blue	425-500	91, 5	1098	2,	28	6,	74	1200	2, 700
Green	500-550	94, 6	4938	0,	16	5,	266	5220	4, 560
Yellow-Orange	550-650	91, 6	16460	0,	37	8,	1473	17970	15, 830
Red	650-750	99, 0	1634	1,	16	-	-	1650	1, [illegible]
White	380-750								

The spectral diagram, i. E. The characteristics of the individual light chambers were recorded by spectroradiometar J. N. C. O. Model SR (USA). This spectroradiometer also used to determine the energy values of the individual parts of a given spectrum, as well as the wavelength at which maximal energy is obtained in the individual light spectra, and the respective maximal energy values as can be seen from the data in Table 2 .

Tab.2. Corrected values (μ W cm -2 nm-1) in light chambers of the Institute of Biology, University of Novi Sad

Light spectrum in nm		Violet	Blue	Green	Yellow-orange	Red	White
Violet	380	0, 79	0, 07				0, 63
	400	1, 47	0, 05				4, 62
	425	0, 10	1, 20				4, 90
Blue	450	0, 02	2, 11	0, 05			4, 40
	475		1, 19	3, 96			4, 33
	500		0, 32	12, 06			4, 62
Green	525		0, 02	2, 39	0, 11		8, 22
	550			0, 22	5, 55		25, 8
Yellow Orange	575			0, 02	19, 10		27, 0
	600				18, 85		20, 68
	625				13, 70	0, 05	13, 30
	650				7, 10	0, 17	6, 29
Red	675		0, 02	0, 02	3, 17	0, 83	2, 83
	700		0, 07	0, 15	1, 32	1, 59	1, 20
	725	0, 02	0, 09	0, 21	0, 77	1, 44	0, 70
	750	0, 07	0, 15	0, 34	0, 52	0, 70	0, 40
M a x		400/1, 47	440/5, 40	520/12, 60	590/21, 00	710/2, [illegible]	580/27, [illegible]

The volume of each climatic chamber with different spectral compositions of light is 21.64 cub. M., with an area of 10.80 sq. M. And a table for growing plants 3.85 sq. M. In area.

Studies dealing with the effect of light of different qualities are highly important from both the theoretical and the practical point of view. Plants produced in nursery or in sheltered space can be grown with a controlled structure of spectral composition of light in the earliest period of their life, after which possible aftereffects can be expected in a certain direction, depending on the quality of light. Some results point to the useful influence of violet light in the earliest period of life of some vegetable gardening plants.

However, if the optimal structure of the light spectrum for the synthesis of organic matter is found, both in quantity and quality, it becomes possible to manufacture material with the necessary capacity for transparency to certain light spectra, and to use such material in building equipment for plant production under artificial conditions. This would clearly be of great practical importance in producing plants in greenhouses constructed from both glass and plastics, since both glass and polyvinyl material could be produced so as to possess different characteristics of absorption, reflection and transparency in relation to certain parts of the solar spectrum.

In addition to the above mentioned 7 chambers - phytotron units with controlled light quality manufactured by the firm Votsch, we possess a chamber from the same firm with adjustable temperature control in the root zone and in the aboveground part zone, a1.410 of non-standard production, as well as chambers with different light qualities. In this chamber the temperature can be regulated in the range of 0-35°C in the different zones. The intensity of illumination is 11.000 lux, the light sources being Silvania Gro Lux. The chamber has no air humidity control. As has been stated above, the temperature in the root zone is kept constant, with variations of + 1°C and equally so in the zone of the aboveground part. However, if the chamber door is opened, the temperature in the zone of the aboveground part changes depending on the temperature of the surrounding space in which the chamber is located, because of the mingling of air. The chamber must be opened at least once a day, since it has no system for air circulation.

It has already been pointed out that studies of different temperature regimens in the zones of the root and aboveground part of the plant are of great practical importance. It is of considerable interest to determine the temperatures in different profiles of the growing medium in which the root is situated when plants are grown in sheltered space, because in that case the heating of greenhouses can be regulated most economically - a fact which may play a significant role in making the industrial growing of plants more economical.

The other four chambers are standard products of the firm Votsch.

The chamber VICZP02/158 is provided with xenon lamps; the intensity of illumination can be programmed within a range between 3.000 lux on the floor to 40.000 lux. The maximal illumination intensity is 80.000 lux. The temperature can be regulated between -20 to + 50°C, and depending on the temperature, the relative air humidity can range between 10 and 95%. In this chamber it is possible to program the intensity of illumination and to imitate daylight. It can also be used to regulate the CO_2 content and to make observations of its consumption on the part of plants.

The "phytotron" chamber VKPHO/2250/S has a xenon lamp with a maximum illumination intensity of 40.000 lux. The temperature range of control is from -20 to + 50°C, the relative air humidity can range from 10 to 90%. The size of this chamber is 1.5: 2.00; and 2.25 cub. M.

The chamber VKZPH/005/53 has fluorescent tubes with a maximal intensity of illumination of 11.000 lux. The temperature can be regulated from -5 to + 50°C , the relative air humidity from 10 to 95%.

The chamber "Ecophyt" VEPH/01/1000 is provided with fluorescent lamps with a maximal intensity of illumination of 27.000 lux, with a temperature range Of -10 to + 45°C. The relative air humidity is 40-95%.

In recent years plant production under artificial conditions has developed in very different directions ; depending on the production method, it ranges from classical models to hydropons and aeropons, while the greenhouse structures vary from the standard ones to the most fantastic shapes.

Greenhouses in which certain parameters can be controlled are also very useful nowadays for research into numerous problems of plant production under natural conditions. Finally, specialized greenhouses are now very much in use in botanical gardens for growing and keeping plants from different parts of the world.

In recent years there has been a steady increase in the construction and use of greenhouses in which certain temperature, illumination, and relative air humidity conditions can be controlled. At the Institute of Biology, University of Novi Sad there are greenhouses (which are considered to be phytotron components) produced by the firm Henssler in 1970. The total area of these greenhouses amounts to 1000 sq. M., that of vegetation houses to 500 sq. M. The sheltered space in which plants are grown consists of 6 separate greenhouses, each 150 sq. M. In area. In these greenhouses the temperature can be regulated from 20 to 30°C as desired through the year, with variations of + 2-3°C. The intensity of natural illumination in such greenhouses can be regulated automatically by lowering and lifting a shading device; if the intensity of natural illumination is over 30.000 lux, the device is automatically lowered, and if it drops below 10.000 lux the device is lifted. Additional artificial illumination is provided by using Ostam light sources of 700 W each, which are placed in a special apparatus and which do not have a heating effect. By using these lamps an intensity of illumination is achieved amounting to about 25.000 lux. Automatic regulation is also possible of the time of switching the light on and off, depending on the length of the extended illumination time. The relative air humidity cannot be regulated, but its values are within a suitable range thanks to the cooling system of the greenhouses. In these greenhouses the following plant species have been grown successfully hitherto : wheat, maize, alfalfa, sugar beet, tomato, grape vine, sunflower and many others, for various purposes of research into problems of plant physiology, breeding and selection, phytopathology, entomology, phytopharmacy, etc..

- o -

XII. PHYTOTRON AT AGRICULTURE CANADA'S RESEARCH STATION, Lethbridge, Alberta

Dr. A. M. Harper

Research Scientist and Chairman, Phytotron Committee, Research Station, Agriculture Canada, Lethbridge, Alberta T1J 481

One of the most complete phytotrons in the world is included in the office-laboratory complex now under construction at the Agriculture Canada Research Station, Lethbridge, Alberta.

The phytotron is not a single unit but consists of 11 greenhouses with a total area of 1950 m2; 11 low-temperature plant growth cabinets with a temperature range °C; 38 cabinets and 5 growth rooms with a temperature range from 5°C to 40 C; and 4 plant growth rooms and 12 propagation rooms with a temperature range from 10°C to 40°C. The plant propagation and growth rooms have an area of 288 m2 and the growth cabinets 125 m2. In addition, there are 36 environmental rooms with limited light and temperatures ranging from -40 C to 35C. A summary of the sizes and performance of the equipment, apart from the greenhouses, can be obtained by writing to Controlled Environments Limited, 1461 St. James Street, Winnipeg, Manitoba, Canada R3H OW9.

All plant growth rooms and cabinets have 35.000 lux of light, and all propagation rooms 25.000 lux, at 60 cm below the light banks. The lights are adjustable for height above the plants. There are both incandescent and fluorescent lights in the plant growth cabinets that are controlled so that either can be shut off or used at 1/3, 2/3 or full light intensity . Light and temperature can be cycled automatically.

The low temperature plant growth cabinets will be used in studying winter survival of crops, especially winter wheat. This work involves development of techniques to induce cold resistance and to identify factors that are important in controlling cold resistance in the field. This knowledge will enable more accurate screening tests for winter hardiness to be developed. Another facet of the work on cold resistance is to determine the biochemical and genetic mechanism by which plants develop cold resistance. Monosomic and chromosome substitution lines of winter wheat are available for the genetic studies and the biochemical studies are in progress but are limited by lack of facilities at present. Alfalfa will be tested for cold tolerance and resistance to crown rotting fungi. The effect of low temperature on growth rates of various crops will be determined to identify genotypes with good growth at 10°C or lower. This will permit an acceleration of breeding and selection of lines capable of early germination and rapid seedling growth.

Four plant growth rooms have 3.4 m high ceilings and will be used to grow tall crops to maturity. Corn plants that have survived exposure to low soil and air temperature will be grown to maturity in these rooms. Also, it will be possible to make pollinations to produce inbred lines and hybrids at any time of the year. These facilities will also be used to compare yields of inbred lines that have been identified as superior in field trials the previous summer. The rooms will permit studies of soil moisture movement, root distribution, and nutrient uptake by various plants grown under controlled conditions and at near-normal depth of root zone. Soil texture, chemistry, and moisture variations throughout the rooting zone will be studied to show their effects on root characteristics and top growth.

Five plant growth rooms, each with four sets of soil-temperature tanks, will be used to study release and availability of various plant nutrients, germination and seedling development of new varieties of crop plants, and the interactions between different aerial and root zone temperature regimes with respect to plant growth.

The plant propagation rooms will be used to increase progenies of cereals and to test them for disease reaction. During the winter, these rooms will supplement the California winter increase program, which cannot be used for selection for disease resistance.

Small, mobile growth cabinets will be used to rear the insect and mite vectors of virus diseases such as barley yellow dwarf and wheat streak mosaic. These cabinets will be housed in a "virus vector" facility designed to reduce cross contamination of cultures and to prevent the escape of the vectors to other plant growth areas.

The plant growth cabinets with higher temperature ranges will be used to study the effect of temperature and photoperiod on growth and development of forages, cereals, and row crops and their reactions to infections by diseases and infestations by insects. The growth cabinets and nine associated insect-rearing rooms will be used to rear insects for extraction and identification of sex pheromones and to study life cycles of insects on plants, chemical and biological control, and to determine amounts and effects of damage by varying levels of insects or diseases on plants are different stages of growth.

XIII. THE INTERNATIONAL RICE RESEARCH INSTITUTE PHYTOTRON AT PHILIPPINES

Editor's Note. Dr. ShoUichi Yoshida, Officer in charge of the Phytotron has sent to us a users' Guide from which we have taken the following information for our readers; those who want more details please write to : Dr. ShoUichi Yoshida, The International Rice Research Institute. Phytotron. P0 Box 933. Manila. Philippines.

Introduction

The IRRI phytotron is a non sterile type. You can bring necessary experimental materials in the phytotron without fumigating them. But this does not mean that you can bring in undesirable insects or diseases freely. Please take every step to prevent any possible hazards in the phytotron.

Facilities

The phytotron has 32 separately controlled growth areas totaling 275 sq. M. and has a gross area of 1.040 sq. M. Each growth area is provided with tap water, demineralized water, and nutrient solution. In addition, it has five dark rooms, one spray room, one chemical balance room, one open-type preparation area, one cold room, and one electric oven . The mezzanine will be used mainly for storage of various items.

Glasshouse rooms

Six glasshouse rooms, each 40 sq. M. Provide ample space for experiments with temperature control. Combined with dark-rooms, they make daylenght control possible .

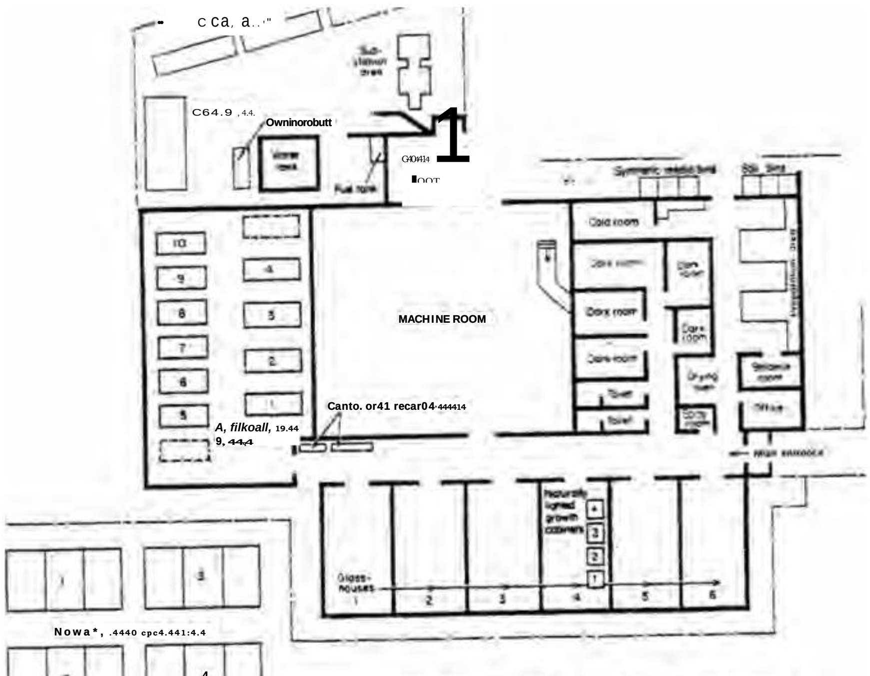
The temperatures in each glasshouse room can be controlled within the range indicated below :

	Day	Night
Room 1 and 6	27-37°C	22-32 °c
Room 2 and 5	21-31°C	16-26 °c
Room 3 and 4	15-25 °C	10-20 °c

The accuracy of temperature control will be + 1.1°C in the plant growing area.

Humidity is not controlled, but will have a low limit of 70-90% relative humidity.

Irradiance (light intensity) inside the room will be at least 80% of incident solar radiation.



IRRI PHYTOTRON BUILDING PLAN (SEPTEMBER 1974)

Naturally *lighted growth cabinets*

Four Koitotron KB-10 D cabinets are housed inside one glasshouse room. Each has a plant growing space of 67 cm x 66 cm x 100 cm high.

The Koitotron KB-10 D provides more precise control and a wider range of temperature. Day temperature will be controlled between 10 and 35°C when the glasshouse room is maintained at 20 C.

The temperature controller for this cabinet has a sensitivity of + 0.2°C. Humidity is not controlled but will have a minimum of about 60% relative humidity.

Irradiance inside the cabinet will be less than outside the cabinet because incident solar radiation has to pass through one additional layer of acrylic plastic. If the acrylic plastic layer has a transmission of 80%, irradiance inside the cabinet will be about 64% of incident solar radiation.

Four Koitotron 3SA-L cabinets are placed outside the phytotron building. Each cabinet is provided with daylength control and has three separately controlled compartments. Each compartment has a plant growing space of 125 cm x 125 cm x 220 cm high.

Day temperature and humidity in each of the 12 compartments will be separately controlled over the range of 15 to 45°C and 55 to 75% relative humidity. Night temperature will be controlled over the range of 10 to 40°C.

The accuracy of control will be + 0.5°C for temperature and + 7% for relative humidity.

Irradiance inside the compartment will be at least 80% of incident solar radiation. Two incandescent lamps are provided for daylength control.

Artificially lighted cabinets. Koitotron KGZ06

Ten Koitotron KG-106 SHL-D are placed inside the phytotron building. Each has a plant growing space of 120 cm x 120 cm x 200 cm high. Themazimum illuminance will be at least 50 klx at a distance of 1 meter below the light bank with a spectral composition similar to sunlight. The illuminance can be varied either by use of screens (30, 50 and 75% transmission) or by automatic floor shift. Day temperature will be controlled over a range of 13 to 45°C with an accuracy of + 0.5°C. The humidity control of 3 cabinets will be made between 30 and 70% over a fairly wide range of temperature with an accuracy of 7% relative humidity. The humidity control of other 7 cabinets will be made between 45 to 80% with similar accuracy.

Darkrooms

Five darkrooms are located opposite the glasshouse rooms. The average size of each darkroom is about 6.5 sq. M. Temperature will be controlled over the range of 10 to 40°C.

These darkrooms will be primarily used in combination with glasshouse rooms for daylength control. They will also be available for any other purposes upon approval of the officer-in charge.

Other facilities

Spray room has an area of about 4 sq. M. It will be primarily used for spraying chemicals (herbicides, insecticides, fungicides, etc) on experimental plants.

Cold room has an area of about 9.4 sq m and will be maintained at about 4 °C. Each user is requested to periodically check his material stored in the cold room.

Electric oven accomodates 84 trays, each 74 cm x 30 cm x 7 cm. It will be maintained at 70°C and will be operated 24 hours a day.

Preparation area of about 32 sq m has an easy access to the cold room, the chemical balance room, the electric oven, and the glasshouse rooms.

The preparation area will be used for sowing, potting, observing, and measuring the experimental plants, and other similar activities. Some equipment such as top-loading balance, leaf area meter, and plasticware are placed in this area.

Operation and maintenance

All the controlled environment facilities in the phytotron will be operated 24 hours a day. During night time one technician will be attending the operation.

When there is a power interruption, two 500-KW generators will provide electricity for the full operation of all facilities.

There will be a 1-month "break period"every year during which time all the facilities, equipment, and recorders will receive a check-up.

Laboratory equipment :

. Lambda L1-170 Quantum/Radiometer/Photometer

By changing sensors, this meter can measure radiation intensity in units of lux, watts m^{-2}, and Einsteins (photosynthetically active light).

Summary

	No. Of units	No. Of compart-ment/unit	Floor area per compartment (sq m)
Naturally lighted glasshouse	6	1	40
Koitotron KB-10 D	4	1	0.44
Koitotron 3SA-L	4	3	1.62
Koitotron KG-106 SHL-D	10	1	1.44
Dark room	5	1	6.50
Spray room	1	1	3.95
Chemical balance room	1	1	9.04
Preparation area	1	1	31.5
Cold room	1	1	9.40
Electric oven	1	84 trays	0.225 per tray

. Honeywell Portable Humidity and Temperature Meter Model 477A . This instrument can measure air temperature and relative humidity.

. Windmeter Model 5101
This instrument can measure wind speed and air temperature.

. Thermo-psychrometer

Three wet and dry bulb psychrometers Model HMT 11 and one recorder Model ERB 6-30 -203.

. Toa pH meter Model HM6A

. Leaf area meter (owned by the Plant Physiology Department)

A leaf area meter Model AAM-4 is available for use in the preparation area. .

Assman's aspiration psychrometer.

. Eppley spectral pyranometer and recorder.

Space allocation

Space is allocated through the officer-in-charge. When planning an experiment a written schedule should be submitted to the officer-in-charge 2 months in advance of the projected starting time.

In general, all sowing and potting should be carried out in the preparation area where growing media and plastic pots are provided. Seedlings may be raised in one of the glasshouse rooms. When the plants are grown outside the phytotron and then brought in, the utmost attention should be paid to prevent insects and diseases from accidentally entering. Even slight carelessness could be disastrous to all experiments in the phytotron. All the plants grown outside should be sprayed with insecticides and fungicides just before they are brought in the phytotron.

The IRRI Phytotron is a gift of the Australian Government and was built at a cost of approximately US$1.4 million. It was dedicated on 23 September 1974. The Phytotron will be used to help man perceive with greater understanding the interactions of the rice plant and the climates in which it grows.

- o -

XVIV. CONTROLLED ENVIRONMENT ROOMS FOR FOREST TREES I

R. J. Cameron and D. A. Rook
Forest Research Institute, Rotorua, New Zealand

Introduction

The new laboratories of the Institute include three large controlled climate rooms designed for the growth of trees up to 7 m tall (Plate 1). Installation of the plant is now complete and in use since 1973.

The need for a special laboratory to investigate the "phytotronics" of woody species was outlined in a submission by Richardson (1964) to the round table conference on phytotronics in London, sponsored by UNESCO. He emphasized the need to study physiological problems associated with mature trees and with their perennial habit and suggested that growth rooms were required where trees could be grown up to at least 6 m tall and in which environmental conditions could be varied in different parts of the tree (roots, stem, and branches).

The main controlled climate facility available to the staff of the Forest Research Institute at present is the laboratory of the Plant Physiology Division of the Department of Scientific and Industrial Research located at Palmerston North, 320 km distant. Experimental investigation of aspects of tree growth (vegetative propagation and transplanting problems) has proceeded there since June 1971, but since the dimensions of the climate rooms preclude work with plants taller than 2 m all work has been with seedlings, grafted seedlings, or roots cuttings. Similarly the conventional growth cabinets at Rotorua (3 CSIRO pattern LB and LBH cabinets, and 3 DSIR (NZ) designed cabinets) can accommodate only small plants.

The 2 m limitation of the maximum size of tree which can be grown under controlled conditions in these facilities places a severe restriction on the *use* of this type of equipment in forestry. There is a rapidly increasing volume of published work on the effect of the environment on the growth of young tree seedlings (e. G. Hellmers, 1962; Brix, 1971) , but there is a complete lack of this type of information for older and larger trees. The large climate rooms at Rotorua have been built to assist in extrapolating work with young seedlings carried out in growth cabinets and in the controlled climate laboratory at Palmerston North to the growth of mature trees. In turn extrapolation of the result with trees from our large growth rooms to the growth of trees in the forest will be at least in part dependent on using the intermediate step of growing the same clones of trees outside the laboratory under continual observation on a site *where* the meteorological conditions are closely monitored and a limited amount of manipulation of growth can be made. The three large growth rooms therefore are not an isolated and independent installation but make up part of a much larger facility for studying tree growth under laboratory and field conditions.

TECHNICAL DETAILS

The internal dimensions of each of the 3 rooms (Figs. 2 and 3) are 3.7 m square(horizontal section) and 8 m high from the floor to the light screen, so accommodating trees some 7 m tall, exclusive of root system. They are constructed of reinforced concrete, insulated externally and clad in metal sheathing on a timber frame. Wooden battens are fixed to the interior wall to permit a light-reflecting liner to *be* attached. Initially a fibre-glass reinforced aluminum foil will be used. The aim is to have an inexpensive liner with good reflectance properties, which when dirty can be replaced easily and at low cost.

The exterior wall of each growth room is fitted with a counter-balanced door, 2.40 m wide and 3.25 m high, which slides vertically and, when closed, fits tight against neoprene seals. Each room has an open-mesh steel floor capable of carrying more than 8 tonnes weight, which can be moved vertically by electric motor from ground floor level to a height 6 m above the floor.

The growth rooms have not been designed as high performance units. Their intended purpose is to support the growth of small trees under definable and reproductible conditions within the range of those obtaining in N.2. Forest during the period of the year when timber species, *Pinus radiate ,* in particular, are exhibiting most active height and diameter growth (September to April). There is no intention to investigate tree growth at limiting conditions of, for example, temperature or light intensity. Such work would be better pursued in the Climate Laboratory at Palmerston North where a very wide range of conditions can be set up with precision, but this does impose the limitation of having to work with smaller plants.

Figure 4 shows, in schematic form, the arrangement of a growth room and how conditions within it are maintained.

Lighting

Only artificial light is provided with the specifications calling for a radiation intensity at the top of the rooms of at least 100 K lux. Each lighting rig as installed, consists of 162 400-watt internal reflector mercury vapor lamps (Philips HPLR-N) plus 24 150-watt low heat output incandescend lamps (Philips PAR) the latter being evenly distributed throughout the lighting rig and arranged on a separate timing system, so providing photoperiodic lighting as well as supplementary red light for photosynthesis. The non-ballasted incandescend lamps can be increased to a maximum of 162 per rig (Fig.3).

The ballasts for the mercury vapour lamps are mounted on thick aluminum plates in separate cabinets fitted with individual air circulation/venting systems, so dissipating heat.

Each lighting rig can be withdrawn on an overhead rail system for checking light operation, for maintenance, or for reconstruction using different lighting units.

A screen of heat-toughened plate glass, 0.64 cm thick, and subdivided into 12 panes, each 0.9 m x 1.2 m, is supported on a steel frame, which separates the growing space from the lighting rig. The lamps are cooled by a high velocity (340 m3/min) stream of filtered air through the lighting rig.

Outlets are provided for the installation of up to 8 kw of fluorescent lighting, laterally within each room.

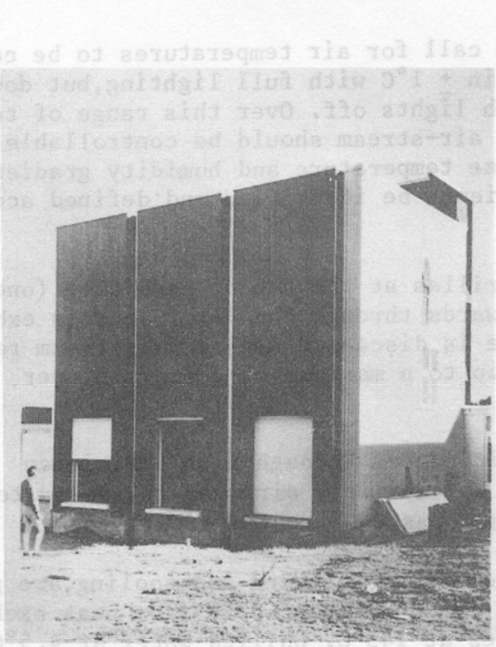


Plate 1: General view of controlled climate room.

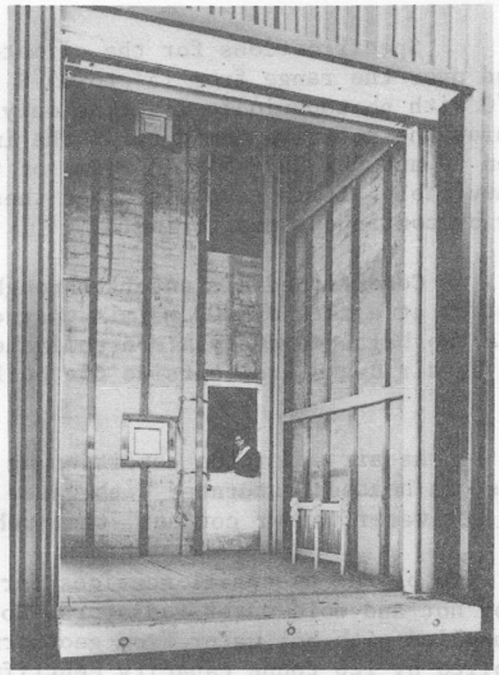


Plate 2. View into controlled climate room through the exterior door showing the wooden battens on the concrete walls to which the light reflecting liner will be attached. Entry to the rooms from inside the building is available through doors at the ground and first floor levels; entry ports for cables etc. are also available at these two levels.

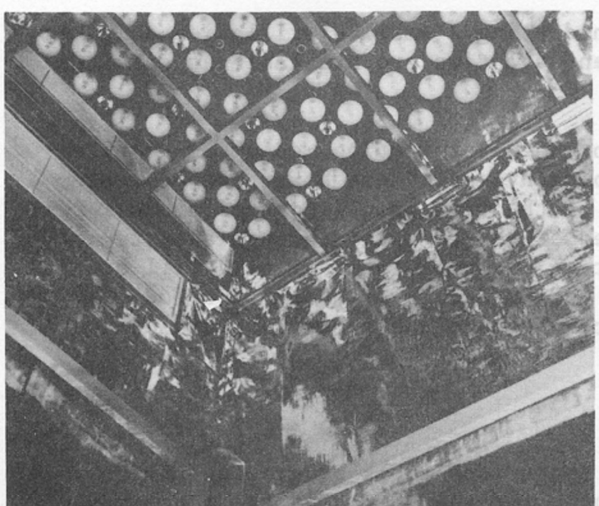
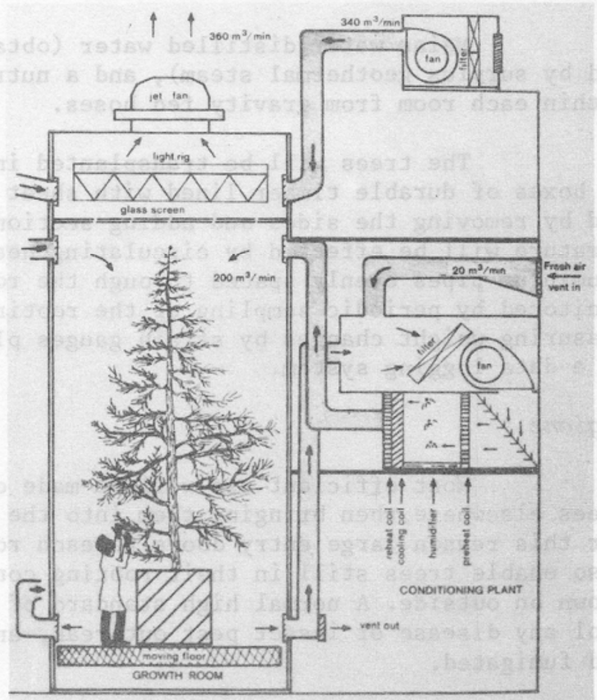


Plate 3. View of lighting rig with one of its air inlets as seen from within the controlled climate room through the glass screen. The aluminum foil liner has been fitted within the room and the air inlet grille and part of the support structure for the movable steel floor are also shown.



Temperature and Humidity

Specifications for the climate rooms call for air temperatures to be controlled over the range from 15° to 35°C to within + 1°C with full lighting, but down to 10°C with photoperiodic lighting only or with lights off. Over this range of temperatures the relative humidity of the incoming air-stream should be controllable between 60 and 80% RH + 5%. In rooms of this size temperature and humidity gradients are inevitable. It is essential that these gradients be identified and defined accurately by continuous monitoring.

Conditioned air enters through two grilles at the top of each room (one at each side) at a rate of 200 m3/min., passes downwards through the floor, and is exhausted via two balanced ducts. A controllable volume is discarded and the airstream replenished by air drawn from outside the building, up to a maximum of 20 m3/min. per room.

As air enters the conditioning plant it passes through high efficiency filters, is heated, saturated with water vapour by capillary air washers, cooled to give a *set* water vapour content, then reheated and passed into the growth room.

Two of the essential services for conditioning air, heating and cooling, are provided by hot and cold water radiators. Hot water is supplied at 82°C from heat exchangers supplied with hot water from geothermal bores at 143°C. Chilled water at 4.5°C is supplied by 120 tonne capacity centrifugal chillers. Duplicate installations (bores, heat exchangers, chillers, and circulation pumps) provide for maintenance and plant breakdowns.

At a later date a carbon dioxide injection system, monitored by infra-red gas analysis may be installed, and under such, control a system of closed circuit air-conditioning can be employed.

Water and Nutrient Control

Mains water, distilled water (obtained using a small distillation unit heated by surplus geothermal steam), and a nutrient solution are available as services within each room from gravity fed hoses.

The trees will be transplanted into whatever rooting medium is required in boxes of durable timber lined with sheet polyethylene. These boxes can be expanded by removing the sides and adding sections as the tree grows. Control of soil temperature will be affected by circulating heated or cooled water through a system of aluminium pipes evenly spaced through the rooting medium. Moisture levels will be monitored by periodic sampling of the rooting medium and, over shorter periods, by measuring weight changes by strain gauges placed beneath the containers and connected to a data logging system.

Hygiene

Most efficient use will be made of the growth rooms by growing the potted trees elsewhere then bringing them into the rooms for the period of the experiment. For this reason large entry doors to each room were incorporated in the design, which also enable trees still in their rooting containers to be removed from the rooms and grown on outside. A normal high standard of glasshouse hygiene will be employed to control any disease or insect pest outbreak, and if necessary each room can be sealed off and fumigated.

Emergency Power Supply

In the event of a mains power failure, an Emergency power supply from a standby 112 kw diesel electric generator would allow continued air conditioning within the rooms and the photoperiod lights only to be run.

Data Logging

A 50-channel data logging system which utilizes a punched paper tape output will be used to monitor both plant operation (on and off-limit detection system), conditions within the growth rooms, and instruments set up to measure physiological responses in the trees under investigation. A computerized data processing system is available at the Institute.

WORK PLANNED

The forest Research Institute operates under a research programme which is revised every three years. Priorities change. Currently the physiological problems being investigated are concerned with producing better planting stock, not only to provide higher quality plants to give perfect post-transplanting rates of survival, but also to extend the planting-season. Consequently our interest is in the physiological changes that occur in seedlings during the "conditioning" treatments that are standard in most New Zealand forest nurseries (van Dorsser and Rook, 1972). This work includes evaluation of the ability of the seedlings to withstand the stresses imposed during lifting, storage, transport, and transplanting, with the primary objective of improving nursery practices still further. Priority is also being given to investigations of the physiology of root initiation in cuttings of *P. Radiata* . As time passes priority will be transferred to study problems associated with trees older than at the seedling stages.

It is not possible, therefore, to give any long term assessment of how the growth rooms will be used but the following problems, listed in approximate order of priority, are likely to be investigated.

(a) Efficiency of Root Systems

Afforestation through vegetative propagation of *P. Radiata* is now a practical proposition (Thulin and Faulds, 1968; Fielding, 1969). It is important that any matters likely to affect the economics of such practices should be investigated thoroughly and factually. The growth of plants of seedling stock and rooted cutting origins will be compared with special emphasis being placed on examining the efficiencies of their root systems at water and nutrient uptake and how they affect shoot growth. Large clonal differences can be expected and much of the work in this project will in cooperation with tree breeders to select root systems with different characteristics.

(b) Physiology of Large Trees

All our studies of the physiology of *P. Radiata* have been concerned with small plants, either seedlings or roots cuttings. It is likely that many aspects of tree growth depend upon the size of the plant, e. G. Remoteness of root and shoot from each other; differences in the environment of root and shoot. Such investigations depend on the ability to grow trees of a suitable size in definable, reproducible environments.

(c) Timber Quality

The quality of timber in *P. Radiata* varies with the geographical locality in which the trees have grown . Such differences arise through variation in wood density, in the relative proportions of summer and latewood, in branch size, in tree form, etc. This variation could be due to temperature, day/night temperature differentials, water deficits, photoperiod or other climatic factors, or to soil fertility, or to some, as yet unresolved influences.

(d) Pathology

From time to time it may be necessary to investigate pathological problems using large trees. Already there is evidence that *P. Radiata assumes a* greater resistance to the defoliating fungal pathogen, *Dothistroma pini* , as trees age, and it is possible that some part of such change can be attributed to the size of trees per *se,* either because of microclimatic effects associated with tree dimensions, or from some less obvious cause.

REFERENCES

Brix, H.1971. Growth response of western hemlock and Douglas fir seedlings to temperature regimes during day and night. Canadian Journal of Botany 49: 289-94.

Fielding J. M.1969. Factors affecting the rooting and growth of *Pinus radiata* cuttings in the open nursery. Forest and Timber Bureau, Canberra, Australia, Bulletin n°45 , pp.38.

Hellmers, H.1962 . Temperature effect on optimum tree growth. In "Tree Growth", Ed. T. T. Kozlowski. Ronald Press Co., New York, 275-87.

Richardson, S. D. 1964. Phytotronics of woody species: Dendrotron, Phytotronique:Compte rendu de la table ronde tenu avec l'aide de l'Unesco, Londres, 1964. Publ. Editions du Centre National de la Recherche Scientifique, Paris, 1969, P.76.

Thulin , I. J. and Faulds, T.1968. The use of cuttings in the breeding and afforestation of *Pinus radiata.* New Zealand Journal of Forestry 13 (1): 66-77.

van Dorsser, J. C. and Rook, D. A.1972. Conditioning of radiata pine seedlings by undercutting and wrenching: description of methods, equipment, and seedling response. New Zealand Journal of Forestry.

- o -

XV. ASHS GROWTH CHAMBER COMMITTEE AWARDED RENEWAL OF NSF GRANT

Editor's Note.

Professor T. W. TIBBITTS from University of Wisconsin. Madison, write. Following announcement :

"A Growth Chamber Use Committe, NCR 101, has been organized under the U. S. Department of Agriculture, Crop Research Science, in the North Central Region of the United States. This committee is comprised of botanists, plant pathologist, horticulturalists, agrononists and agricultural engineers concerned with problems with growth chamber use. The committee is working to develop procedures to insure uniformity and repeatability in growth chamber experiments. The committee is meeting annually, with the next meeting in Beltsville, Maryland at the USDA Plant Stress Laboratories on February 28 to March 2, 1977. The officers are T. W. Tibbitts, University of Wisconsin, Madison, Chairman; P. A. Hammer, Purdue University, Lafayette, Indiana, Vice-Chairman; and M. E. Duysen, North Dakota State University, Fargo; North Dakota, Secretary, T. E. Hazen, Iowa State University at Ames, Iowa is the Administrative Advisor for the Experiment Station Directors.

The ASHS Special Committee on Growth Chamber Environments has been awarded, a 541.700 two-year renewal of their grant for Baseline Growth Studies, by the National Science Foundation. The grant will run until April 1978. The studies are directed toward developing procedures to insure uniformity in growth chamber research. Studies to date have been undertaken with "Grand Rapids" lettuce and "First Lady" marigold in peat-lite culture. Ongoing studies are being extended to other crops in this mix and to the development and utilization of continuous-flow liquid systems. A significant portion of the funds are utilized for the maintenance, distribution and regular calibration of a package of environmental sensing instruments that are exchanged among the cooperators to insure uniform environmental measurement. Funds are also utilized for chemical analysis of plant *tissue* at UCLA in CA, computer analysis of data at Purdue, IN., and for the rental of space in the Biotron at Wl. And Phytotrons in NC. The cooperators in the studies are :

-W. L. Berry. University of California
-V. Bonaminio. North Carolina State University
-P. A. Hammer. Purdue University
-H. Hellmers. Duke University
-R. H. Hodgson. USDA. ARS. Fargo
-D. T. Krizek. USDA Beltsville
-R. W. Langhans. Cornell University
-R. A. Larson. North Carolina State University
-J. C. McFarlane. EPA Las Vegas
-D. P. Ormrod. University of Guelph. Canada
-T. W. Tibbitts. University of Wisconsin

If you are desired more details contact :

T. W. Tibbitts
Horticulture Dept.
University of Wisconsin
Madison, Wl, 53706

- o -

XVI. ESNA. EUROPEAN SOCIETY OF NUCLEAR METHODS IN AGRICULTURE

We received from Secretariat of ESNA Proceeding 1975 which summary are give below :

-Meeting of working groups 6 (applied mutagenesis) and 8 (Nuclear Methods in Fast routine analysis of Biological material) in Hannover, may 12th 1975 by E. G. Niemann(FRG)

-Joint FAO/IAEA Research Coordination Meeting on isotopV Tracer aided studies of foreign Chemical residues in Food, Agriculture and Fisheries in Vienna (Austria) 20-24 october 1975 by Prof. S. Puiseux-Dao.

-Esna Sixth Annual meeting september 8-12th 1975 Cadarache (France)

-Opening address by Pr. P. Guerin de Montgareuil

-Official address by Mr. P. Balligand
Report of the Chairman D. De Zeeuw and the secretary P. H. Van Nierop Nuclear Agriculture in the French speaking part of Africa and Madagascar by R. Maignieu.
Nuclear agriculture in Poland by S. Moskal
Recent developments in agricultural documentation and information with particular regard for "Nuclear Methods in Agriculture"by H. Buntrock.
-Report of working group 1. Food irradiation by D. De Zeeuw (The Netherlands) Report of working group 2. Radiation induced stimulation effects in plants by J. Simon (Hungary)
Report of working group 3. Tracer techniques in animal sciences by M. Jovanovic (Yugoslavia)
-Report of working group 4. Radiation analysis by W. Kuhn (FRG)
-Report of working group 5. Soil plant relations by M. J. Frissel (The Netherlands)
-Report of working group 6. Applied mutagenesis by C. Broertjes (The Netherlands)
-Report of working group 7. Environmental Pollution by C. Myttenaere (Belgium)
-Report of working group 8. Fast routine analysis of biological Material by E. G. Niemann (FRG)
-Report of working group 9. Genetical methods of pest control by R. J. Wood (UK)
-Report of working group 10. Radioisotopes in insect ecology by L. A. Buscarlet (France)
-Report of working group 11. Nuclear methods in plant physiology by R. Antoszewski (Poland)
Final session by E. G. Niemann
-Meeting of Esna Committee september 12th 1975.

Those readers who desire more information please write to: Secretariat of ESNA :

Institute for Atomic Sciences in Agriculture (ITAL) Wageningen. PO Box 48. The Netherlands.

o -

XVII. REVIEW OF SEMINARS ON "STUDY GROUP ON ROOTS"

This study group has just published a review of the seminars in Nancy in 1974 and in Grenoble in 1975 in three volumes.

Volume 1 by A. Fourcy. Microanalyse dans les Vegetaux. (Ionic and electronic sensors, laser and mass spectrometry, R. P. E. in vivo, radioactivation, radioactive double marking) 77 pages.

Volume 2 by J. Gagnaire Michard and A. Riedacker. Methodologie. Morphogenese (Rhythms of growth and regeneration, workings of root systems) 265 pages.

Volume 3 by A. Riedacker and J. Gagnaire Michard. Physiologie des racines (Problems posed for nurserymen, horticulturists and foresters) 54 pages.

Readers desiring more information about these works are invited to inform themselves at : Groupes d'Etudes des Racines , Laboratoire de Biologie Veg6tale, CEN in Grenoble BP 85X-38046. Grenoble, Cedex, France.

XVIII. ECONOMICS : CAN SCIENTISTS SUCCEED WHERE ECONOMISTS HAVE I FAILED ?

R. R. W. Folley. Senior Lecturer, School of Rural Economics and Related Studies, Wye College, University of London. UK

Editor's Note. Having sent us this text, the author would like us to publish it as a "trial operation". We are publishing it in this context, in no way wanting to transform our publication into an media for polemics.

- o -

The reference to economics in the admirable Newsletter n° 12-13 suggests that a number of scientists are poised on the threshold of economics.

The writer sees no virtue in a long, involved and inconclusive statement concerning the uses of economics. Much along these lines has been written by people seeking effective use of funds for scientific research and later development (R. And D.). Arrow (1962), de Veer (1970). The following contribution is intended to be brief, simple and self-evident. It is manifestly impossible either to discuss all science or to give a complete account of economics.

He also acknowledges that commercial production of plants, although an economic activity, is dominated by natural-science research. The scientific effort, which leads to progress in technique, is now too well established to permit the emergence of a parallel effort by economists. The way is open for science and economics to become symbiotic if some scientists would like to move in that direction. Some expeperiences with economics would be salutary. For instance, notwithstanding the quantum of science- based research into the heated tomato crop, recent economic progress by Dutch producers owes far more to the necessity to reduce labour costs than to progress in technique.

Norris and Vaisey (1973) in fact assert "the ordinary learning process" to be one of the best agents of economic progress.

The Director of a Science Research Establishment will know as well as anyone some principles of economics. His is the classic case of a fixed capacity (for research) relative to the number of projects which could be undertaken. He has to exercise choice, and he will soon develop his own system of priorities. As a scientist he will be most in favour of projects of high scientific value.(This loose expression may be exemplified by projects designed to fill troublesome gaps in existing knowledge which are holding back future developments thought to be more important).

In such a case a Director is exercising economics-like choice but has the privilege of doing so according to his own system of values. He cannot be said to be making economic decisions in the usual sense of the term unless he is applying the conventional system of values upon which the national economy operates. For many economists, the market place is a focal concept because it is there that relative values (prices) are determined. Several thinkers have tried to visualize scientific research as a commodity having a market in which the projects on offer are priced according to their value to the community Fishel (1971). A little of the same principle, surely, is to be found in the Rothschild (1971) proposals for a shift in agricultural research in Britain. Although camouflaged by the principle of "accountability" , the real effect of the proposals was to increase the quantum of research inspired from conventional values as distinct from secular scientific values.

A Director will also learn from experience of the principle of Diminishing Returns, albeit in terms of the importance of the scientific content of discoveries. Every project has its apogee- sometimes long-delayed- whereafter the Director will be torn between the virtue of completing the work and the time it will take to do so.... with little added that is new. If the Director is aware not only of diminishing returns but of how the extra time might be more advantageously spent, he ranks as an economist- in-science.

The case of the Phytotron is interesting because phytotronic endeavour is science in excelsis : the equipment provides the ideal medium for factorial experiments leading to step-by-step acquisition of reliable knowledge. If economics can be linked with science when science is at its most scientific the same formula should apply equally well over the rest of the spectrum of scientific work.

But before scientists become too involved in economics, it must he remembered that economics has disappointed a lot of people. Its grandest theories have not been able to prevent, or to cure, the current global economic recession. And at the other extreme, the production principles constituting the "Theory of the Firm" have proved inappropriate to extension work and passed into disuse.(In order not to leave a loose thread here, it may be added that national economics has become merged with other disciplines of thought into Politics, and production economics has given place to a more liberal discipline, Management), In other words, scientists are advised to check their present ideas about economics.

The substance of economics

The State and the firm figure again in the following two statements which are intended to summarize the motivation of economic research :

1. The ultimate aim of economic research is furtherance of national welfare;

2. Efficiency of production must continually improve if the quantum of welfare is to increase.

Both statements are tautological but perhaps require interpretation for scientists.

National welfare criteria plunge the scientist straight into the social milieu : his views in this field, if any, will be non-scientific. Well-intentioned scientists may be excused from joining in the arguments about the distribution of wealth (i. E. Between workers, proprietors and so on) but would still be concerned with the creation of wealth. Their part in the latter would be to organize an "economie WEATishment.

Efficiency of production requires each firm to he technically efficient and also to attain accepted levels of value-productivity from its resources. Efficiency of production is thus a little different from plant productivity. Highly-productive plants are desirable but both technique of production and organization of production can probably contribute as much to efficiency as plant productivity.

The research program of a director trained in economics would probably have different accents from that of a scientist, as follows (assuming the co-operation of the staff);

a. Less fundamental research and more effort towards evaluating results (i. E. Technology, or development);

b. Fewer factorial experiments: less attention to environmental/physiological relationships and more attention to alternative ways of improving resource productivity,

c. Time saved on micro-experiments and given to experimental production systems ;

d. With respect to crops grown in controlled environment, a close study of the rates of physical-and value-substitution of other productive factors for (a) temperature and (b) sunlight.

In short, the economist would (at first) be more aware of non-scientific ways of promoting production efficiency. His organization would quickly become multi-disciplinary and he would be more content than the scientist with empiricism. (Please note it is assumed here that there is one economist-director among many scientist-directors. The postulated changes in accent are not a general recommendation-that would be completely presumptuous. In any case, starting now, after a period of twenty years the economist's and the scientist's programs would no doubt be very similar)

An example : research into energy-saving

The many references in Newsletter n 12 + 13 to energy-saving in heated greenhouses indicate that scientists might feel they are applying economics when their aim is to maintain the profitability of production. In this context what scientists are actually doing is tinkering with the applied-scientific edifice they have created for producers. They are offering science-based solutions to an economic problems. Scientists certainly have one foot on the economic ladder when they work with conventional values and when they determine (pp.38-42) the relative advantages for heat retention of single and double plastics film and panes. Among economists, this sort of partial value-assessment of management decisions ranks as Farm Business. The work would be closer to economics when the full consequences for the firms concerned are determined by when the full consequences for the firms concerned are determined by using energy- saving equipment and comparing it with the same holding without such equipment. It can thus be seen that the German producer cannot escape heavy additional expenditure in "saving" energy, for, using Plexiglass panes for example, he spends $U. S.16.000 (equivalents) per ha and saves $4.000 per ha. His cash expenses increase by $12.000 per ha in the first year and he is at the same time committed to more intensive production, for the estimated savings are dependent upon high temperatures being maintained in the greenhouses : his risk is increased along with his investment and he is entitled either to a higher reward or to greater economic security.

Basically , (says the economist) if producers of protected crops are in financial difficulty, it is because their industry is using too many resources relative to the value of the product . It thus seems irrational to increase the investment, even though the partial substitution of energy in the form of plastic panes for energy in fossil fuel makes the greenhouse a more efficient converter of energy.

For comparison, the economist would aim to reduce resources and to increase the product's value, but as the latter is closer to marketing than to production, nothing more will be said about it here. With respect to production, the economist sees a necessity to shed resources until a secure base is reached, whereafter appropriate methods of improving efficiency can be introduced and production and consumption can increase again. This comment endorses the previous statement that an industry needs to be resource-efficient as well as to have technically efficient firms.(The writer contends that if producers were as well versed in applied economics as they are in technology they would be more adpatable and more prepared for common action than at present).

To return to the main theme. For his dream to be realised, the economist would want to know input-output data for each industry. He would seek systematic and integrated data upon several economic states of the industry. He would *wish* to see how a moderate energy, moderate employment, lower-consumption , higher importation situation compared from the national point of view with a high and low levels of use together with the possibilities of substitution between factors within each situation. This is the context for the use of the data for experimental production mentioned in the postulated economist's program for research.

Plant environment studies

In the special case of a phytotron, it is tentatively suggested that there is little difference in concept between the economist's "production mix " and scientist's "factor-interaction". In practice, however, the economist would perhaps think it more important to simulate specific climates (e. G. Morocco) and make comparisons of plant growth on this basis than (for example) to isolate the effect of a mean temperature 5° C higher. The ensemble of the living plant is a laudable objective for the scientist to pursue : but if he follows this road he will at some point lose the company of the economist.

With efficiency of production in mind the economist will have less cause than the scientist to isolate the 'n' th. Trace element in plant nutrition. Assuming that sophisticated methods of detection have been necessary to isolate it in the first place, the economist would not regard it as commercially important. In the more realistic instance of the study of air movement through a crop canopy, the focal point for the economist is the marginal exchange of (fragments of)resource. An improvement in efficiency arises from a beneficial exchange of part of one factor for part of another. These possibilities of marginal substitution between factors constitute the economic approach to production technique. In the case in question, assuming constant temperature, humidity and CO_2 concentration or the atmosphere, the energy cost (not the airspeed) of different frequencies of air change would be compared with the change in the value of the crop produced.

To substitute value-exchanges for exchanges of physical quantities would result in more marked differences in the utilization of phytotrons when at an advanced stage of research, de Bilderling's (1975) ideas of mathematical models for plant production become feasible. The scientist's formulae will relate to maximum output per plant. Since area is often a limiting factor in practice, maximum physical output, possibly later modified by maximum value- output per unit of crop area, is important to the economist. Only if scientists work in the knowledge of the constraints imposed upon producers will the scientist's and the producer's optima be the same. One of the lessons of experience with production economics is that maximum profit on the farm is rarely, if ever, associated with maximum use of any single factor. It appears that a good balance of factors associated with high but not maximum use is the most profitable way of organizing commercial protected cultivation.(It would seem that economists could possibly have the role of acquainting researchers with the commercial constraints, but the writer has no knowledge of this being done).

Towards a dialogue

The dialogue between science and practice which eminent applied scientists are seeking is hindered by two obstacles- in temporal order, technology and economics.

Technology can here be disposed of with a reference to the bionic man of TV fame: the Controller enunciates: "We have the technology : we can rebuild him" (i. E. Not the science).

Economics is not, like technology, a temporal extension of *science,* but forms a sort of trinity with the two. The scientists who recognise this trinity will be more concerned with adding economic value to their work at its origin than with subsequent economic valuation of science-inspired *results.*

This is the sense in which scientists can succeed where scientists have failed. Farm economist's resources do not allow them to explore the applied-scientific alternatives of economic decisions. Scientists have much larger resources and to the extent that they pursue economic ends would be in a position to succeed where economists had failed.

A dialogue will be one-aided, nevertheless, if it consists of scientists discussing their results ex post with non-scientists. A fruitful dialogue will arise only when both or all parties know in advance the kind of results expected: but before this stage is reached scientists will need to have learned the trick of asking the right question at the outset. Non-scientists will need experience of what science cannot do.

At this point scientists must be warned in advance about the transitory value given to the economic derivative from a physical fact. Once scientists attach importance to economic derivatives they risk the scientific content of a discovery becoming out-of-date along with the economic content. The maintenance of an economic status quo (the so-called "up-dating" of data) is a necessary and repetitive economic exercise and is often defeated by the highly- evolutionary state of the economic world.

Success for scientists

If the above comments have succeeded scientists will be aware that (a) the results of scientific experiments are like a photograph of the tip of an iceberg, and (b) economics has its own mysteries. Good economics is most likely to be associated with good science when either.

a. On a comparatively small scale, applicable to single firms, scientific results have a definite place in (a model of) a production system for which input/output data are required in association with a recognized technique and form of production organization ;

b. On a comparatively large scale, applicable to a sector of the economy or to a constituent industry, scientific results enable either a change or a shift or productive resources to be made within the economy and thus add to the well-being of the population.

Thus, if scientists can learn to be satisfied with probabilities where they have previously accepted nothing less than reasonable certainty, and can accept questionable social-goal weightings for research instead of scientific curiosity, they will be in a position to contribute to the conditional type of result appropriate to an awareness of elusive and changeable economic values.

This conclusion is not a re-statement of the platitude that in order to move closer to practice scientists must liaise with producers. Feedback from producers has its place in "problem-oriented" research. There is a similarity in approach- an approach not in the best traditions of science, but economics-inspired research projects would be much larger than "problem" projects, the inspiration being "the felt needs of society"(Tavistock (1964).

Most of the foregoing, of course, is gratuitous comment when science-based research is carried out with a declared economic purpose. National plans for economic development through modern technology are a prime example. On a smaller scale, the decision to develop horticulture in Languedoc- Roussillon and integrate the necessary scientific research is another instance. In the writer's experience, however, such instances are rare: most research proceeds more autonomously.

Bibliography

Arrow K.(1962) Economic Welfare and the Allocation of Resources for Invention in the Rate and Direction of Economic Activity. Princeton Univ. Press; pp.609-625.

de Bilderling N. (1975) R8le des Phytotrons dans l'Industrialisation de la Culture protggee. Annales de Gembloux, 81 pp.155-172.

de Veer, J.(1970) The economic evaluation of research in the agricultural sciences and of extension work. Meded & Overdruk L. E. I. Den Haag, 57.

Fishel W. L.(ed.) (1971) Resource Allocation in Agricultural Research. Univ. Minnesota Press, Minneapolis.

Norris, K. and Varsey J.(1973) The Economics of Research and Technology. Allen and Unwin, London.

Rotschild, N. M. (1971) A Framework for Government Research and Development. H M S 0 London.

Tavistock Institute of Human Relations (1964) Social Research and a National Policy for Science. Pamphlet n°7, London.

Editors'Note. As indicated at the beginning, the ideas set forth by the author <u>does not commit anyone else than himself.</u> Readers desiring to exchange ideas on this controversial subject should contact the author directly at the following address :

Professor R. R. W. Folley
School of Rural Economics and Related Studies
Wye College, Ashford Kent Wye 812401
STO 0233 U. K.

o

XIX. PLASTICULTURE & RESEARCH NEW OBJECTIVES

by Prof. Dr. Ir. A . NISEN

Chairman Working Group "Plastics in Horticulture"ISHS
Faculty of Agronomy, Dpt Horticulture. Institut Agronomique de l'Etat Gembloux 5800 Belgium

I. What is plasticulture ?

Plasticulture is the name given to a technique which consists in using "plastics" in agriculture in whatever form.

From a target, plasticultivation has rapidly grown into a means, and then into a true need; from a hesitating technique, it has turned into an accurate and complex science. Indeed, it is connected with many a field and calls upon a lot of diversified techniques.

It is about to gain a world-wide surprising importance; it raises quite a lot of problems and implies the setting of numerous and diversified experiments and researches.

Indeed, plastics occur under various forms :

-sheets , rather thick plates (1-2 mm), therefore rather rigid or very thin films (0, 05-0, 2 mm) , quite flexible of limited width (plates) or practically una;117a width, short-lived (a few months) to semi-long-lived (2-3 years: films or 10 years: plates).

-nets : i. E. Gauze of more or less thick yarns, the air or light permeability of which fits the need.

-pipes : their thickness, flexibility, durability, resistance to chemicals or climatic agents can be varied nearly at will.

-cans : containers, bottles, flasks of various shapes and presentation.

These new materials are used in many a way in agriculture : greenhouses and large shelters, small tunnels, soil mulching , protection of crops from animals (anti-bird nets) or from climatic factors (wind shield, shading net, anthihail cloth) , ensilage, fruit preservation, building of water reserves, drainage, irrigation, soil disinfection and improvement, packaging (of fertilizers, phytosanitary products, fruits and vegetables...) , various applications in building , new applications (rice farming, tea, rubber yielding plants...).

II. How do plastics work ?

The role played by the materials commonly called 'plastics" obviously depends on the type of application considered.

The building of shelters-large or small-enables an improvement of the thermal balance of the crops-to a certain extend depending on the climatic conditioiii-OT the region where it is carried out- and makes possible the growing of out of season if not counter-season crops.

Obviously, the influence of the shelter on the water balance of the crops is not to be neglected but can be seen as secondary, except under low latitude or under arid climate.

For its part, ground mulching with plastic films seems, at mid-latitude to be aimed mainly at improving the water balance of the crops with, as secondary effect, an incidence upon the soil temperature conditions except, however, in the higher latitude regions.

Moreover, for the time being, plastic pipes (films or rigid) or drainage or irrigation play an already important role in modern agriculture, role which will undoubtedly become more and more important as the technicity of the developing countries increases.

Finally, the other applications of plastics in agriculture mentioned above call upon the various properties of these synthetics. Their discussion would take us out of the frame of the present work.

III. Importance of plasticulture

Although the result of such an estimate can always be questioned, for 197!, one can evaluate (1) at about 35.000 Ha the area covered, in the world, by greenhouses or large plastic shelters at about 75.000 Ha that on which small tunnels covered with films have been built and, at last, at more than 200.000 Ha that where plastic films are used as soil mulching.

According to the surveys, more than 300.000 Ha were, in 1971, protected in some way by plastic covering.

These areas are unevenly distributed throughout the world; a very rough picture of this distribution is given in table 1.

Many countries have not yet had the opportunity of developing their plasticulture while others, such as Japan, claim for hardly credible amounts of plastics in agriculture.

To the above mentioned applications (buildings-large or small, mulching) one must add the applications recalled in & 1 and mainly drainage and irrigation . It is impossible to express that amount in Ha; this amount is evaluated at 100.000 tons plastic, this would represent 1/5 - 1/4 of the total amount used fat agricultural purposes.

For guidance, let us note that- still in 1971- one could estimate at 15.000 Ha the total area (for its main part concentrated in Northern Europe) covered with greenhouse or glass buildings.

From 1971 to 1973-4 (1), large and small shelters for crops hale multiplied, even more than the mulched areas, mainly in the regions having a climate of the Mediterranean type. Nowadays, throughout the world, the area covered with plastic shelters of more or less important size can be estimated at 150.000 Ha (while the area covered with glass is only 17.000 to 20.000 Ha). For its part, the soil mulching technique would be used on practically 250.000 Ha (the half of which in Japan) which brings to a present likely total of 400.000 Ha the total number of Ha where plastic materials are intensively used for the protection of crops.

1971/Ha	Greenhouses and large shelters	Small tunnels	Mulching
North Africa	200	1.500	100
North America (USA)	2.500	2.250	60000
South America (Argentine)	500	100	50
Asia (Japan)	14.000	40.500	100000
Australia	?	?	1000
Western Europe	11.500	19.000	37500
Eastern Europe	11.000		?
Middle East	2.000	3.500	1500

Table 1 : Distribution of plasticulture in the world.

For their part, plastics used for irrigation techniques- when compared with those used in 1971- have also seriously increased.

To wind up the matter, the world yearly consumption of plastics for agricultural purposes must, in 1973-74 , top the 800.000 Ton level , the 3/4 of which as films.

These global values need no comments, more exactly they raise so many '', 2) (3) that we will limit ourselves to the following remarks:

1)Protected crops-initially concentrated in Western Europe, in the regions of more than 50° latitude-have gradually moved towards the mid-latitudes (30^{2}45°) as plasticulture developed and conquered other continents.

2)In the same time, the use of glass as a covering material for houses used for the protection of plants increased much more slowly and was restricted to the high latitudes or continental climates.

3)Plastics have been an element for the vulgarization of the crop protection technique in the developing countries- as soon as and in so far as they have enabled a reduction of the investment required for the building of shelters.

4)As far as plastics are concerned, we see the mulching technique as an even more important contribution than the covering of plants with shelters for it interests larger areas, more uniformly spread through the various latitudes and it is likely to conquer the **arid** or semi-arid zones where it will play a major role in the years to come.

IV. Present problems in plasticulture

We think that it is unnecessary to insist upon the fact that the improvement of the outputs and the quality of crops, together with the lengthening of production periods and widening of production and regions ***seems*** much more important that the price increase resulting from a higher precociousness obtained in the rich countries for the out-of-season crops, mainly for early products.

In our opinion, this thought is likely to prove more and more correct in the course of the years to come during which the main efforts to make should be devoted to the development of new production opportunities -mainly in vegetable- in new countries less industrialized; this would lead, first, to a better nutrition of their people, afterwards to an increase in their standard of living.

It is in the arid regions that this phenomenon proves the more important and pressing; to tell the truth, we do not deal with an increase in the standard of living of the populations, we deal with their very survival.

I would be sorry not to evoke here the call for international help made in the June issue (n°XXII) of "Plasticulture (1) by D. Clarke, honorary member of the U. K. and Malaysia associations for the promotion of plastics in agriculture and U N I D expert (United Nations Industrial Development Organization).

Various bodies of the United Nations have, indeed proposed long-term means to fight starvation in the vast Sahel region (Sudan) where 15 million human lives are threatened. One of these proposals is to derive maximum profit from the water available in order that more cultivation can be made in these dry or arid regions.

As seen above, it seems that one of the best ways to achieve this goal is the use of plastics as crop covering (decrease in evapotranspiration), as mulching (in order to limit the losses by evaporation from the ground) or as irrigation material (decrease in water losses in the irrigation system by evaporation or percolation) and even as raw materials for the manufacture of bags or plastic packages for the transport and conservation of food.

V. Plasticulture and Research

In the euphoria caused by the discovery of a brand-new tool and with the help of the plastic industry (which at the beginning saw in agriculture a new and not too demanding market for its standard products), European agricultural craftmen and technicians have, from 1955 to 1960 , worked in a very extended order.

They have made a lot of demonstration cultures in more or less large shelters covered with plastic films but, unfortunately, there, they took their inspiration from the glass-covering techniques.

These centrifugal and superficial demonstrations have been the object of reports both numerous and partial which, though they enabled the discovery of the real properties of plastic films used as ground or plant covering, did not make possible the drawing of general objective conclusions likely to lead to any valid extrapolation. In our mind, these studies have just proved that the new plastics could not be used the way glass is, that they could not simply replace glass, that, in fact, conventional materials and new products were not competing, but complementary, the former doing here what the latter could only do in other ecoclimatological conditions and vice-versa.

Thanks to the gradual development of symposia first on a national scale, then soon on an international level, symposia organized by the "Committees of plastics in agriculture" which have progressively been created in the more active countries, it became possible to group, orientate, bring under control and, above all, to coordinate all these scattered tests.

The agronomists have come to help the researchers in their laboratories of the firms which produce or transform plastics and agriculture could gradually profit by the products made for it as function of its needs. sine qua non condition of success in plasticulture.

Today, the industrialized world disposes of a vast capital of knowledge in all the fields of plasticulture, capital which, in our mind, seems improperly used because it is insufficiently codified and indexed.

Also, the industrial world profits by an important infrastructure which makes possible fundamental research of the highest interest.

VI. Future objectives of research in plasticulture

It is utopia to think that developing countries as well as people from arid or desolated regions could in a near future profit by the experience gained in plasticulture by the industrialized countries ?

For sure, the answer is no I However, we do not think that the conventional ways of scientific research will enable this humane performance.

Yes indeed, it is good to carry out further fundamental work along the ways shown by financial interests or the programs of experimental stations which deal with practical problems of plasticulture.

But the new goal mentioned above i. E. The introduction at the shortest notice of plasticulture in arid or semi-arid regions seems to us to require new working methods, a new conception in international scientific collaboration.

As plasticulture does well on such an important area and under such a various climate, has the time not come to draw up a true and systematic inventory of our present knowledge, to classify, codify, standardize it... ?

To achieve this goal, we suggest the drafting of technical cards which would state in a concise form easily understandable to anyone the information which the technicians should dispose of when they want to keep to a minimum the hesitations of the initial stages, to shorten the experimental phase and to tackle, without any accident risks, the practical achievements first on a demonstration level, then on the industrialization level.

The major obstacle against which the possible makers of this inventory might stumble doesn't lie in the very importance of the work to be carried out but in the - disinterested and synthetic mihd which it requires from its authors.

As we have personally been the promoter of a tentative for the drafting of a technical card similar to that proposed at point 3 of the following table (4), we know that this is no easy job.

But we feel that this step is actually essential and likely to solve, in a short time, the first problems which crop up when plasticulture is adopted in the new conditions of countries which suffer from starvation.

Certainly, the technicians in these countries will have to improve gradually the basic realizations, to refine the details; this might be necessary just in order to take into account the human factors, the habits or aspirations of the populations concerned. **But**, at the beginning, many hesitations -i. E. many time losses-will have been avoided.

Is an international body as I. S. H. S., which group so many scientists from all parts of the world , not suited for sponsoring and organising this inventory ?

VII. How to carry out this inventory ?

In our long introduction, we have summarized the various aspects of plasti - culture. In our mind, the first three items dealt with (greenhouses and shelters, small tunnels and mulching) took the most important and the best suited for forming the backbone of this inventory which should consider the constant elements of plasticulture i. E.:

-the plants cultivated
-the materials used -
the shelters built.

The other elements seem to us to belong either to the field of fundamental research (new formulations of plastics, techniques for conditioning the shelters) or to that of applied research if not vulgarization (ideal periods of cultivation, complementary techniques for cleaning, fighting the phytoparasits.,).

As a preliminary, it seems possible to define a limited number of climates having own characteristics and to select them as basic references representative of the conditions of the "natural climate" likely to be recorded in the field. Starting from these few and well defined types of climate, it should be possible to carry out studies -which we will call "qualitative"- a subdivision of these macroclimates into "meso" if not into regional or local microclimates, leading subsequently to secondary information which we would call "quantitative".

Hereafter, we will call reference climates these well distinct types (temperate, maritime, continental, maritime Mediterranean, continental Mediterranean, tropical, desertic).

1. PLANTS	2. PLASTICS	3. SHELTERS
	a) Determination of	
the most important vegetable species, on a world-wide basis and of the most interesting	the plastic types (formulation and commercial forms) which are the most interesting	a few types of shelters of various sizes which can be used
	under the reference climates	
	Characterization of	
the ecoclimatology of these species and sorts according to criteria	the photometric and mechanical properties of these plastics by methods	of the way these shelters modify the main types of climate by methods
	to be standardized on a world-wide basis	
c) Drafting of a technical card Mating the possibilities of use		
for the various cultivars selected	for the plastics selected	for the shelters selected
	under the various reference climates	

Table II. Stages of the synthesis work suggested

Let us comment on these various suggestions :

1°- Plants

a)Some vegetable plants only (tomato, lettuce, pepper, paprika, strawberry, melon, egg-plant) take gradually a considerable and - moreover- universal importance in protected crops. The inventory suggested does not turn out impossible even if the number of cultivars (or rather of cultivar families) to be taken into account under each of the various main type-climates considered as references is a little higher. This restatement looks the most interesting as it would automatically give the research (vegetal improvement) the directions for its future work.

b) Physiological research certainly is important but, in the above mentioned conditions, we think that bioecoclimatoloaical studies are the most urgent. Indeed, we must be able to understand the reaction of the various cultivar families towards the various conditions of cultivation which they are submitted to. We think of their chilling requirements, heat requirements (degrees-day o temperature sums), resistance to thermal extremes, water requirements (transpiration resistance to high and especially to low hygrometrics, light requirements (sums of light, ability to grow under too low or too high luminosity), edaphic requirements (soil fertility, texture and salinity) , resistance to illnesses, to predators. All these items could be codified, standardized on a world basis; this would make their expression much more simple.

c)The final step, the drafting of technical cards based on the adaptation potentialities of the cultivars selected to the climatological conditions created by the shelters under the type-climates is perfectly possible as the data required at point b)are already abundant and the specialists on the spot quire competent.

It would thus be possible to consider the establishment of a kind of "ecoclimatological data bank" for the various cultivars considered.

2º)Plastics

a)At the beginning of the use of plastics in agriculture many a family of polymers have been explored. For the time being, a sharp selection has occurred- we could say owing to the force of circumstances- and the large majority of products worth a mention in the field of shelter or soil covering belong practically either to the polyethylene family or to that of the polyvinylchlorides.

The choice of a limited number of materials in order to draft their technical cards is not in opposition with the need for the creation of national (better regional) quality labels. Here again, we could say that the choice proposed takes a fundamental qualitative outlook while the quality labels concern the less deep, secondary but important point of view, in one word, the quantitative side of the question.

b)For the few types of materials selected, with the collaboration of the agronomical laboratories, it would be important to determine the physical (photometric and mechanical) and chemical characteristics which are important for plasticulture.

The most suitable methods of measurement should also be stated. It is essential that these methods be standardized on a world-wide basis (and no longer at a regional level which prevents any relationship), and remain simple although truly functional. We do not consider here a meticulous scientific research, we draft an accurate but before all practical document.

c)In this manner, the third step could be tackled : the drafting of the technical cards of formulations (the chemical composition of which is defined) and of products (commercial forms of the various formulations).

3º)Shelters

The bringing of plastic films into play i. E. Their use as shelter covering-from the simplest ones which do not require any structures (mulching, film directly on the plant)to the most complex ones (sophisticated greenhouses covering all in one block large areas) leads to the concept of "derived climates" which of course depend on the natural climate under which the shelters are built, on the properties of the covering and on the own characteristics of the shelter (volume, shape, orientation).

a)In a first step, it would be well to standardize on a world-wide basis some main types of shelters the building of which, at the local level, could be rather diversified depending on a rational use of the frame materials available in the relevant country and on the relative importance of the various factors of the climate.

This standardization is far from being impossible. It has been seen, for instance, that some realization3which have been better designed than some others (tunnels of the Nantean type e. G.) have already, for a long time, superseded these less sophisticated constructions.

b)The second step would lead to the definition of the way in which these few type shelters modify the reference climates selected. This should be expressed as a function of the own characteristics of the shelter and of the properties of the cover material used.

c)Finally, the drafting of the technical card of these standardized shelters should, in a last stage, enable to set the practical range of their possibilities and the extent of the human intervention required. It means that one should detail the differences between the "derived climates" generated in the main types of natural climates selected and the climate required by the cultivar families mentioned in 1-c.

We are perfectly aware that the standardization and synthesis which we propose here above is far from being easy and rapid to carry out but we are convinced that the stake of this pooling of the present knowledge (the immediate future of whole populations) justifies its realization and, in advance, valorizes the efforts to be made.

The main stages of this synthesis work are :

1. Selection of the reference climates as a function of the requirements of plasticulture.

2. Determination of

-the species or varieties of vegetable)
-the plastic types) which are the
-the types of shelters) most polyvalent

and the most likely to yield good results in plasticulture under the reference climates.

3. Standardization, on an international basis, of the criteria enabling

-the ecoclimatological characterization of the species and groups of vegetable varieties chosen
-the climatic characterization of the shelters taken as models.

4. Drafting of technical cards stating the possibilities of use of the cultivars , plastics and shelters selected as a function of the reference climates adopted.

VIII. Conclusions

The present study has tried to consider the research problems in plasticulture from the angle of recently defined perspectives i. E. Not only the help to young countries but also, if possible, an attempt to save populations threatened by starvation in arid regions.

It leads to the formulation of a proposal for a collective work at various international levels. This work, owing to the force of circumstances, will raise problems of execution which are not to be neglected.

But it could emphasize the imperative need of a synthesis on a world-wide basis, of a codified and standardized display of the infinity of the data available the scattering of which prohibits their rational use in new countries.

It suggests a means of taking full advantage of this badly exploited capital of knowledge with a view to its application to plans aimed at helping threatened populations. Indeed, is plasticulture not an efficient means to draw a maximum of agricultural productions from a minimum available water under (semi) arid climates ?

It proposes the I S H S to be the stepping stone of this inventory as it calls together the specialists who are the most likely to carry out, successfully , on a world-wide basis, the study proposed.

May the latter be not considered as utopic or pretentions and contribute, thanks to plasticulture, to the relief of starvation in the world

IX. Bibliography

I)Various Authors: "Plasticulture" XVIII (June 1973) to XXVI (June 1975); CIPAParis.

2)Nisen A. :"L'eclairement naturel des serres" Second tirage Presses Agronomiques. Gembloux (B) 1971.

3)Nisen A. & Dogniaux R.:"Traite de l'eclairage naturel des serres & abris pour vegetaux "; Duculot, Gembloux (B), 1975.

4)Nisen A. et al.: "Functional photometric characteristics of transparent and translucent materials used for glazing" (with technical cards) N B N 894 Belg. Stand. Inst. (IBN) Brussels 1971.

- o

XX. SOME THOUGHTS ON THE POTENTIAL USE OF LOW GRADE HEAT FROM NUCLEAR REACTORS

Norman J. Beaton, Associate Professor, Department of Agricultural Economics.
University of Manitoba . Winnipeg R3T.2, 11a. Canada.

Editor's Note. The text of this conference presented during a seminar on horticulture in Winnipeg in November 1975, was sent to us by emeritus professor J. D. Campbell of the Plant Science Dept. of this University. We reproduce with pleasure given its current interest.

- o -

In the past several years, the topic of low grade heat and its utilization has received considerable attention. A recent international workshop held at Atomic Energy of Canada Limited facilities at Chalk River, Ontario, from October 6-10 1975, attempted to grapple with this very topic. Many ramifications were dealt with. Being brief as possible, I will attempt to relate some of these to you.

First, it is necessary to examine what is meant by the term "low grade heat". Generally, low grade heat is heat that is available at less than 100° Fahrenheit. A nuclear reactor creates a lot of excess hear and in order to keep the reactor's temperature in a range where the fission process can be controlled, it is necessary to use vast amounts of water to dissipate this heat build-up.

"Heavy water" is used both to aid the fission process and transfer the heat that is built-up. The chemical formula for water is H_2O and heavy water consists of molecules where the hydrogen atoms are twice as heavy as normal. This is called deuterium oxide (D_20). The heat from the fission process is used to generate steam which turns the turbine. The turbine turns the generator which gives off electricity. The heavy water is very valuable, since only one molecule of it occurs in nature relative to 7.000 molecules of water. Quantities of heavy water are obtained by an expensive distillation process.

Water from a river or lake is used to condense the steam from the turbine back into water. In this condensing process, the river water absorbs the heat from the steam. The temperature of the river water is raised when it passes through the condenser. This is now the water to which we refer to as the source of low grade heat.

A nuclear generating system consisting of four reactors will require approximately 1.400.000 gallons of water per minute for cooling purposes. Expressed in a shorter time span, this is 3.640 cubic feet per second. The mean annual flow of the Winnipeg River at Slave Falls, which is upstream from Pinawa, is 28.300 cubic feet per second (minimum daily of 9.900 c. F. S. And maximum daily of 51.000 c. F. S.) (4). The volume of thermal discharge from the nuclear reactor at Pinawa is approximately 37 percent of the minimum daily discharge of the Winnipeg River. It is estimated that the thermal discharge is 18 to 20 degrees Fahrenheit higher than the water temperature of the Winnipeg River. It is possible for the thermal discharge to enter the river at 90° to 92°F. At this temperature range many native plants and fish would not survive.

The relationship between various energy sources and power (be it in the form of mechanical or electrical power or available in heat) is shown in Figure 1.

With hydro energy, electricity can be produced directly by means of the turbine which drives the electrical generator. The production of electricity with nuclear energy is not so direct. The_ heat from a nuclear reactor is first used to create steam, which in turn drives the turbine. Generating electricity by means of steam is not efficient in terms of the amount of heat lost. When steam is created either by means of fossil fuel or nuclear fission, about two-thirds of the heat contained in the steam is lost to the cooling water in the condenser. Unless this heat now contained in the cooling water finds some practical use, it is loSt, because the resulting hot water must be cooled in some way for re-use or released to the river. Lf it is not cooled before release to the river then thermal pollution is created. A high enough level of thermal pollution can distugb the local environment. This is a problem that will require a considerable amount of research. With a proliferation of reactors, there could be a cumulative effect on the environment. Canada, now has a number of reactors and in the United States there are presently 53 active nuclear plants and construction permits have been issued for 63 more (1).

It has been estimated that the amount of low grade heat available from a 2.000 million watt nuclear reactor is sufficient to heat all of the city of Toronto (3):So, in reference to a nuclear reactor, we are not talking about a limited source of heat.

A nuclear reactor could be the source for heating large urban areas. This is referred to as district heating. District heating is simply heating a community, or part of a community, from one central heating source. District heating with low grade heat may be expensive in terms of initial capital investment for a central heat distribution system, in comparison with individual heating units as with oil and natural gas. What happens when (or if) oil or natural gas become unavailable for heating purposes? The beginning of this phenomenon may have already started. In Winnipeg long term contracts for natural gas are now being restricted in new housing developments.

Low grade heat could have a number of agricultural uses, such as: the heating and cooling of greenhouses as well as animal shelters; field soil warming to lengthen the growing season, by means of underground piping; irrigation of cropland; grain drying; aiding microbiological disposal of plant and animal waste; spraying of fruit trees to protect them from frost damage. These agricultural applications could be inte- 'rated with aquaculture, district heating, industrial or recreational uses.

Several test projects utilizing low grade heat are being conducted in North America. In Alabama, several tomato and cucumber crops have already been grown in a greenhouse heated by water discharged from a nuclear plant. Figure 2 depicts one way of transferring the low grade heat to the greenhouse environment. An experimental greenhouse has been in operation for more than a year west of Edmonton, at Lake Wabanum, that uses the warm water discharged from a fossil fuel generating plant. The water is not warm enough to give good growing results during the winter months but is adequate for the spring months.

At the workshop in Chalk River, a number of ways of utilizing low grade heat were considered. A session on the long-range future derived the following recommendations for consideration :

1. All levels of government must provide more leadership in setting total energy policy.

2. Public utilities must be responsible for the optiditutilization of fuel in the production of heat and electricity.

3. District heating is likely to be khe most significant use of low grade heat in cold climates. The heat requirements of agriculture and aquaculture can be met by district heating. Pilot projects should be initiated in district heating, agriculture and aquaculture.

4. The public should be encouraged to use liquid fossil fuels for mobile power rather than space heating.

LITERATURE CITED

(1) Anonymous. "Energy-Considering the Alternatives". Time. April 4, 1975. Pp.68-69.

(2) 8eall, S. E."Conceptual Design of a Food Complex Using Waste Warm Water for Heating". Journal of Environmental Quality. Vol.2, N°2, 1973.

(3) Dyne P. J. Future Prospects for the Utilization of Low-Grade Heat, paper, Chemistry and Materials Science Division, Whiteshell Nuclear Research Establishment, Atomic Energy of Canada Limited, Pinawa, Manitoba, October 1975 . P.4.-

(4)Environment Canada. Historic Strellflow Summary: Manitoba to 1973. Ottawa: Information Canada , Cat. No. En 36-418/1973-2.

(5)Southwell, P. H. "Energy in Perspective"-. Proceedings of Ontario Institute of Agrologists 15th Conference entitled Energy and Agriculture, Guelph, 1974.

o -

XXI. Effect of CO_2 – CONCENTRATION ON MORPHOLOGICAL, HISTOLOGICAL, CYTOLOGICAL, AND PHYSIOLOGICAL PROCESSES IN TOMATO PLANTS

E. Madsen. State Seed Testing Station. Skovbrynet 20, DK, 2800 Lyngby , Danemark.

Editor's Note. The author sent us this book the subject of his thesis, which can be purchased for 35 Danish kroners (or about $ 5.50 U S) at De studerendes boghandel, Thorvaldsensvej 40, DK-1871 Copenhagen V, Denmark.

For our readers we reproduce below the summary and conclusion of the author (pages 50 and following):

The investigations performed have shown that the morphological, histological, anatomical, cytological as well as physiological changes in tomato plants are influenced by increasing CO_2- concentrations in the air both in the vegetative and the generative stage. It was also clear that the CO_2-concentration in the air affected the chemical composition of the tomato fruits.

The effect of CO_2 -concentrations on the various physiological processes differed; the maximum rates were achieved at different concentrations. Most processes reached the maximum rate between 0.10 and 0.22 vol % CO_2. In some cases the maximum *rate* was, however, achieved at lower or at higher CO_2- concentrations. The maximum effect of CO_2 might be of positive as well as of negative value , when compared with results from plants grown in atmospheric air. The figures 5a and 5. B give a summary of the investigations in relation to results of plants grown in atmospheric air.

As it is depicted in fig.5 . A, the starch content increased almost seven times more than that of control plants. Photosynthetic rate and per cent dry matter was doubled, whereas ascorbic acid and the examined organic acids showed an increase of almost 60 per cent . The growth increment per plant (35 days old)increased about 40 per cent in CO_2-enriched air. The crude fibers content in the stems increased proportionally with the CO_2-concentration in the air, whereas the crude fibers content in the leaves decreased by about 30 percent. A calculation of the crude fibers content in the whole plant showed that a supply of extra CO_2 to the air increased the living leaf tissue in tomato plants.

The content of ashes (mineral substances)calculated as per cent of dry matter decreased, compared with the content in leaves from plants grown in atmospheric air.

The fruit yield increased concurrently with the CO concentration in the air up to 0.10 - 0.15 per cent; above this concentration the fruit yield decreased with the rising CO_2-content in the air. The decrease in yield was so severe that plants grown at 0.32 vol.% COproduced almost 60 per cent less fruits than plants grown in atmospheric air.

A number of other relations with an evident CO_2 dependence is listed in fig 5b. Glucose and sucrose increased in the leaves at elevated CO_2 concentrations. Changes in these carbohydrates affect the osmotic component of the water potential in the leaf cells. Due to a lowered water potential the cells compensate by absorbing water, and the result will be that the leaf thickness and fresh weight per unit area is increased. The same reaction was observed for stomata, epidermic cells and palisade cells. The condition was, however, that the CO_2-concentrations applied did not cause a higher production of chlorophyll or an increased mitosis. The results obtained gave no such indication, and the changes may, therefore, have been caused by the osmotic reaction of the lower carbohydrates.

Table 5. A lists the content of a number of materials in the six lowest leaves which have been used for these investigations . The calculations are made on the basis of

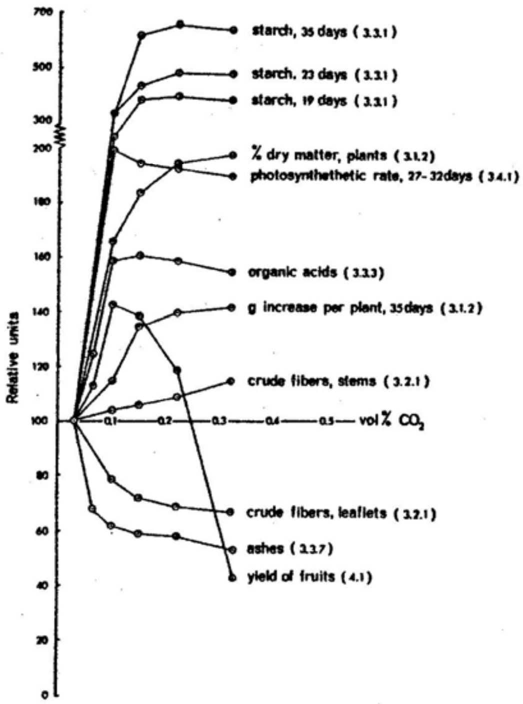


Fig. 5.a Summary of the effect of CO_2-concentration on a number of parameters, in relation to results from plants developed in atmospheric air.

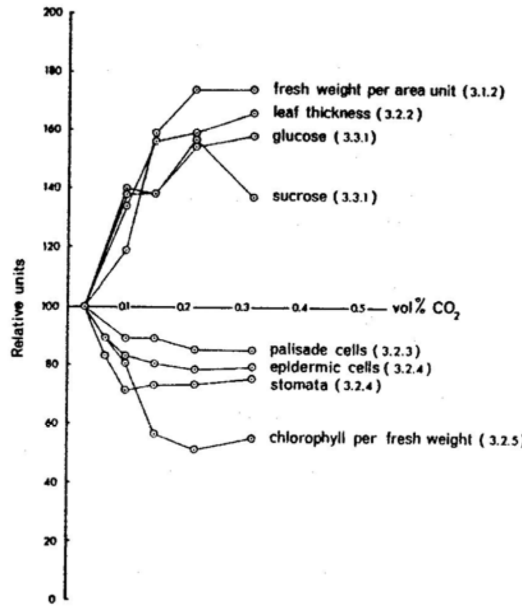


Fig. 5.b Summary of the effect of CO_2-concentration on a number of results with dependence. The results are listed in relation to plants grown in atmospheric air.

Vol% CO_2	0.03	0.065	0.10	0.15	0.22	0.32	0.50
Fresh weight, g	89	95	103	120	125	127	126
Dry matter, g	11.21	16.55	22.45	29.88	33.13	34.42	34.15
Dry matter, %	12.6	17.4	21.8	24.9	26.5	27.1	27.1
Crude fiber, g	0.68	0.79	0.99	1.25	1.36	1.41	-
Starch, g	0.21	-	1.42	3.52	4.14	4.20	4.20
Glucose, g	0.11	-	0.30	0.40	0.50	0.53	0.51
Sucrose, g	0.15	-	0.43	0.56	0.71	0.63	0.62
Org. acids, g	0.23	0.30	0.42	0.49	0.53	0.50	-
Chlorophyl, g	0.32	-	0.30	0.26	0.23	0.25	0.23
Ashes, g	1.49	1.80	1.86	2.36	2.65	2.42	-
Total-N, g	0.55	0.60	0.64	0.76	0.86	0.85	-
Protein, (N x 6.25), g	3.43	3.75	4.00	4.75	5.37	5.31	-
Phosphorus, mg	47	55	56	78	82	72	-
Potassium, g	0.30	0.40	0.37	0.58	0.62	0.54	-
Calcium, g	0.36	0.44	0.46	0.59	0.83	0.71	-
Magnesium, mg	58	68	70	90	123	107	-

Table 5.a Total substance per plant from the six oldest leaves. Age of plants about 1 month. Sampling at 4 p.m.

the quantity of dry matter in the leaflets per plant. The same amount of dry matter per plant was used in all calculations, corresponding to the average of a number of investigations. Samples were picked when the plants were about one month old. The hour of the day for picking is of great importance, and the calculations are, therefore, made on the basis of results of leaves picked at 4 p. M. only.

The fresh weight per plant increased about 40 per cent, whereas the dry weight increased more than 200 per cent when extra CO_2 was added to the air, compared with plants grown in atmospheric air. These increases correspond to a rise in the dry matter percentage of 200 per cent. Compared to this the rise in the crude fibers content, which expresses the volume of dead tissue, was only 100 per cent. The conclusion was that an increase of the CO2-concentration in the air caused a higher amount of li ving leaf tissue in relation to the non-living tissue.

The largest increase caused by extra supply of CO2, appeared in the starch content, which increased 20 times in the leaves, compared with the leaves of the control plants. However, this heavy increase of the starch content constituted only a small rise in per cent of the total dry weight.

The content of glucose, sucrose and organic acids from the citric acid cycle in the leaves showed also substantial increases at elevated CO2 - concentrations.

The chlorophyll content decreased with rising CO_2-concentrations due to a degeneration of the chloroplasts on account of the large accumulation of starch.

Content of ashes in the leaves, which is also an expression of the content of mineral substances, increased when the plants were grown in C02-enriched air, compared with plants developed in atmospheric air, despite the fact that the content calculated as per cent dry matter showed a decrease in the leaves at increasing CO_2-concentrations.

The outcome of the presented results can be summarized as follows- Addition of CO_9 to the atmosphere in which tomato plants grow has great advantages, especially for tfie production of young plants where supplementary light can be given . The advan tage of CO_2 to fruit bearing plants is also profitable, even if its beneficiary effect is only found within a narrow concentration range and is to some degree dependent on the light conditions under which the plants develop. The fruits from plants grown at elevated CO2-concentrations are sweeter, contain less acid, but more ascorbate.

- o -

XXII. COMPUTER-BASED DATA ACQUISITION AND PROCESS CONTROL FOR PHYTOTRONS

Robert L. Schafer and Alvin C. Bailey. Agricultural Engineers, National Tillage Machinery Laboratory, USDA, ARS, SR- Po Box 792. Auburn Alabama 36810 USA.

The rapid development of small computer technology has resulted in the availability of a very powerful research tool at a modest price. Properly integrated into the research situation, the digital computer increases the efficiency of the research process and makes it possible for the researcher to accomplish more in a given unit of time. With a digital computer researchers can accomplish tasks that were previously very difficult or impossible to accomplish. Computers can calculate and present results simultaneously with the research process which can he used for evaluation and/or control of the research process.

In this paper we will introduce some of the digital computer concepts related to data acquisition and process control and relate these concepts to the operation of a phytotron. At this point we must admit that we have not had the experience of using a computer in conduction with a phytotron. However, we have had exposure to the operational requirements of a phytotron. We also have had considerable experience in the use of a real time multiprogramming digital computer for data acquisition, analysis, and display and for process control at the National Tillage Machinery Laboratory.

DATA ACQUISITION AND PROCESS CONTROL IN THE PHYTOTRON

Data acquisition and process control are essential elements in the proper operation of a phytotron. Data are acquired as part of the process control of the various operational or environmental aspects of the phytotron. Process control of such factors as light intensity, daylength, temperature, humidity, plant watering, and wind velocity is necessary to provide the desired environment in the phytotron. Also, data are acquired for recording the behavior of the phenomenon being studied.

Traditionally data for process control and data for describing experimental behavior are collected separately. In addition, separate control systems have been used for each of the various phytotron processes. All of the data acquisition and process control functions could be consolidated with the use of a data acquisition and process control system that is based on a digital computer.

COMPUTERS

To use current jargon, computer sizes range from micros to minis *to* midis to maxis. It is difficult to correlate size with capability; however, the *class* of computer we are discussing ranges from a medium mini to a small midi. We will not attempt to delineate specific hardware and software because the technology is expanding very rapidly and because each research situation has a different *set* of requirements. As we proceed to describe the computer and its functions we have no particular manufacture or model in mind, although everything we describe can be purchased commercially.

The first requirement for the computer is that it must be able to communicate with the real world. We need to control switches, relays, valves, and voltages; and we need to sense contact closures and voltages and measure voltages and outputs from transducers in the phytotron. Thus, the computer must have interfaces for these types of communication with the phytotron. These interfaces would include analog to digital conversion, digital to analog conversion, digital inputs, digital outputs, and contact closure outputs.

Another requirement is that the computer must have a real-time multiprogramling operating system if it is to do anything other than a very simple task. The operating system is vendor supplied and provides for control of the computer and for communication between the computer and the researcher in research terminology. The real-time aspect of the operating system means that control and data acquisition functions are executed based on time of day, elapsed time, or some external event. An effective real-time system must'have response fast enough to appear instantaneous compared to the speed of phytotron events. Thus, the operating system allows a real-world response to real-world requirements.

The multiprogramming aspect allows for execution of a number of programs on a priority basis. Only one program executes at a time; however, real-time programs are often suspended for data input or output or for some other event. While suspended, this program relinquishes computer time to the next highest priority program; likewise, the latter program suspends and relinquishes time to the next highest priority program, etc. Whenever a higher priority program becomes active again, it will stop the execution of a lower priority program and resume execution until it is stopped by a higher priority program or becomes suspended again. Because of the speed of execution of the computer, many programs can be executing on this priority basis, but each program will still maintain real-time response. If necessary, the programs can communicate with each other and can control each other.

The importance of the multiprogramming concept to the operation of a phytotron is that separate programs can be used for the various functions. For example, separate programs might do each of the following: control temperature, humidity, sunrise, sunset, and light intensity; water the plants; and acquire data on the environmental variables and on plant-response variables. The advantages of using separate programs are that one program can be changed without affecting the others, and a small program is much easier to write and debug than is a large one. It would be almost unthinkable for a researcher to write one large program to interface with all the functions of a phytotron.

Another requirement for the computer system is that programming must be done in a high-level language such as FORTRAN. An auxiliary requirement is that the FORTRAN library must contain subroutines that allow communication and data exchange with the real-world interfaces. This high-level language with real-world interface routines is needed so that the researcher does not have to be a computer expert. As far as the researcher is concerned, the computer system should be a black box that provides an easy and convenient means of implementing the research.

THE AUTOMATED PHYTOTRON

With a proper real-time multiprogramming computer system, the phytotron can be automated relatively easily to a high degree. We envision several benefits.

First, one only has to change a program or a parameter input to a program to change a control sequence or a data-acquisition sequence (as compared to a hardware change). Thus, the system versatility that is available is limited only by one's imagination. As an example, the environmental conditions for any geographical location, if known, could be easily duplicated in a phytotron.

Another benefit is the ease of handling the acquisition of data from a nonlinear transducer. With computer-based acquisition the transducer output can easily be converted to physical units if the calibration curve is known. Under some circumstances the transducer output can even be double valued.

Another benefit is that data can be analyzed on-line and the results evaluated coincident with the experiment. Thus, one can make judgments as the experiment proceeds, and errors can be easily spotted and corrected.

• PITFALLS TO BE AVOIDED

As with any sophisticated equipment, some pitfalls must be avoided. In the physical implementation of a computer-based system, the controls should be implemented so that, should the computer fail, the phytotron and the experiment would be guarded from damage. The failure rate of modern computers is quite low, but computers break down occasionally, and the consequences must be controlled adequately.

The computer system must be expandable, because not all the requirements can be anticipated and the research requirements tend to grow. An expandable system costs a little more than a nonexpandable system, but we feel that the increased cost is justified to insure meeting future needs.

The vendor must provide adequate support of his hardware and software. No one has made a perfect system yet, and probably never will. One must be able to get help from the vendor when it is needed, not just . A promise of help sometime.

At least one person who works with the phytotrons must be trained to program and run the system. Probably several people will be able to "make the system go". Howe ver, at least one person must have an in-depth understanding.

A PROGNOSIS

The proper implementation of a data acquisition and process control system that is computer based will be of great benefit to the phytotron researcher. If the system is improperly implemented, the researcher will find it hard to get anything accomplished.

- o -

XXIII. CONTROLLED ENVIRONMENT FACILITIES FOR RICE RESEARCH

P. M. Singh, A. C. Pandya, H. K. Pande and W. A. Bailey

The authors are: P. M. Singh, Post doctoral Research Associate, Dept. Of Agril. Eng., University of Nebraska, Lincoln, USA: A. C. Pandya, Director (Engineering) , National Dairy Development Board, Anand, India; H. K. Pande, Professor and Head, Rice Processing Centre, I. I. T. Kharagpur, India; and W. A. Bailey, Agricultural Research Engineer, U. S. D. A., ARS, Beltsville, Maryland, U. S. A.

ABSTRACT

Design and development of three plant growth chambers which have been installed at the Indian Institute of Technology, Kharagpur has been presented. Two of these chambers are large walk-in type with 2.70 m x 2.70 m x 2.25 m (height) plant growth area. Third chamber is a portable reach-in type with 3.0 m x 0.8 m x 1.20 m (hieght) plant growth area. These chambers have been specially designed to satisfy the high humidity requirements of rice crop in tropics.

INTRODUCTION

The necessity of controlled environment facilities to strengthen the rice research at Indian Institute of Technology, Kharagpur was realized by plant scientists and agricultural engineers in the year 1965 when the efforts were being made to develop new high yielding rice varieties. It was felt that the environmental factors affecting plant growth fluctuate and interact to such an extent that it was very difficult to isolate the effect of each factor separately *unless* some of these studies are conducted under controlled environmental conditions. In this connection, a research project was submitted to the United States Department of Agriculture under PL-480 agreement which was approved in December, 1969, and put to operation in January, 1970. This paper describes the objectives and achievements of this research project on "Study of Growth Dynamics of Rice under Controlled Environment". By now, three plant growth chambers have been designed and constructed, especially for rice growth studies. Two of these chambers are large walk-in types and third one is a portable reach-in type. Design and development of these chambers is the subject matter of this paper.

OBJECTIVES

The present research project was started with the following objectives: (1) Design and development of growth chambers from indigenous equipment for tropical Indian Climatic Conditions. The typical conditions of rice growing season are constant high day and night temperature, low light intensity, and high humidity. There are following points which are related with the above objective, should be critically examined before arriving at the complete design.

a)Choice of insulation to resist molds, fungi under high humidity, temperature ambient conditions.

b)Determination of spectral energy requirements of the rice plant and selection of lamp type *and* phosphor to achieve natural light distribution.

c)Determination of light intensity distribution within the plant canopy.

d)Special design requirements for operation near atmospheric saturation *and* high day temperature.

e)Special design requirements for growing rice under flooded *as* well as unsaturated soil conditions.

f)Selection of refrigeration unit to achieve the designed temperature conditions under saturated air conditions.

g)Determination of ventilation and air circulation requirements for the profusely tillering rice crop.

2)Study of the optimum growth conditions for the rice plant :

a)Effect of following environmental conditions on the growth of rice plant.

i)Air composition and movement.

/Might intensity, quality and distribution.

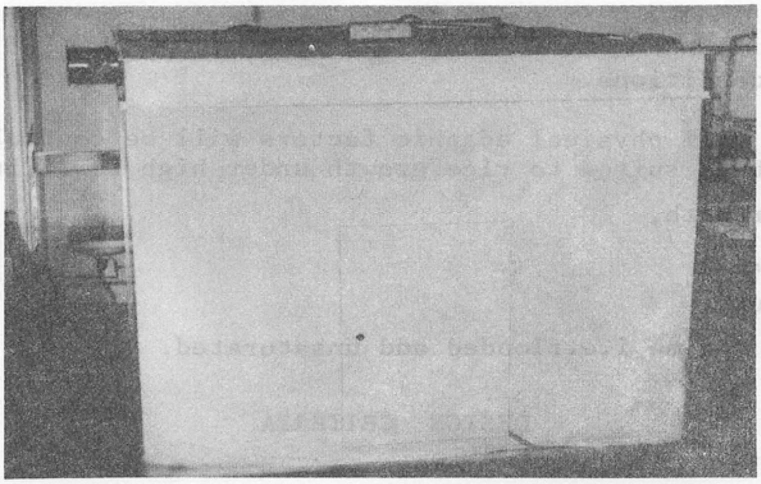
iii)Day, night, air, leaf and lamp temperature.

iv)Humidity.

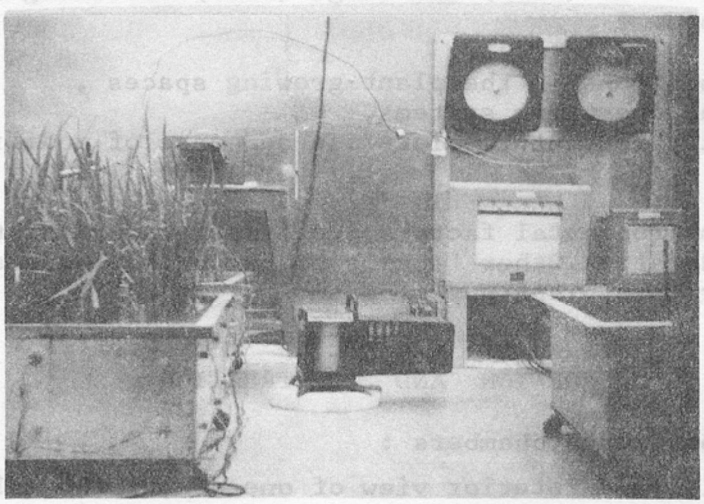
b)Plant growth studies.

i)Study of growth characters of rice plant like number of tillers, beight, leaf area, number of panicles, dry matter production of roots and shoots and sterility under varying environmental conditions.

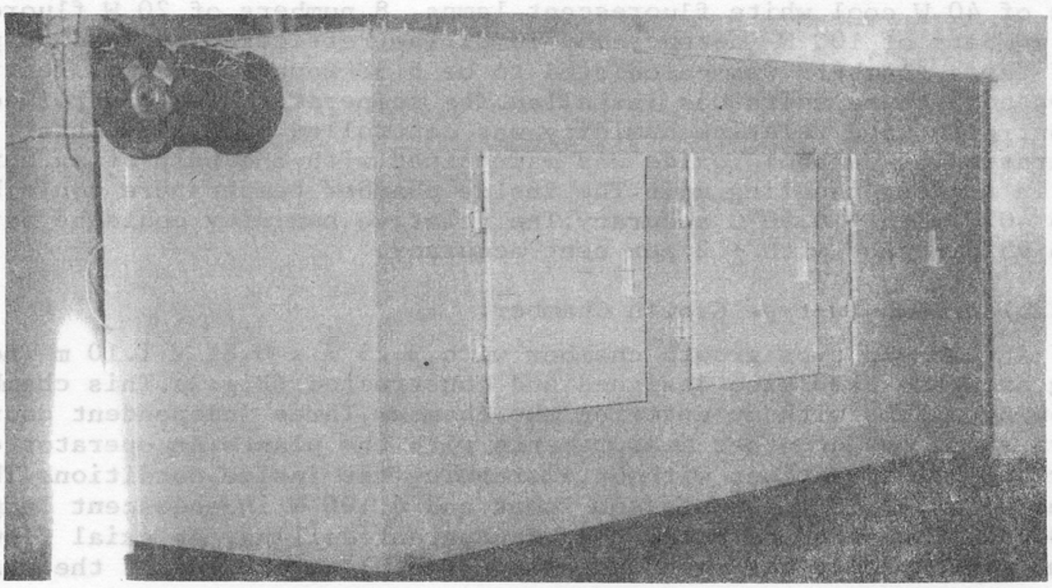
ii)Instrumentation for continuous weighing of each plant or batch of plants and also for continuous measurement of plant movement and growth.



Front view of walk-in type growth chamber



Interior view of walk-in type growth chamber with control equipment.



Front view of reach-in type growth chamber.

e)Soil physical conditions.

Following soil physical edaphic factors will be controlled to specify the physical conditions best suited to rice growth under high fertility level.

i)Mechanical strength,

ii)Soil aeration,

iii)Soil temperature,

iv)Soil moisture regime i. E. Flooded and unsaturated.

DESIGN CRITERIA

The design criteria for these chambers were based on the earlier studies of Morse and Evans (1962) , Ashrae (1964), Bailey, Downs and Klueter (1964), Hellmers and Downs (1967), Klueter et al (1967) and Singh (1969). Following three basic design criteria were established.

1) Uniformity of conditions in the plant growing spaces ,
2) Reliability of the operating systems,
3) Maximum flexibility for intermediate use and ease of modification for updating and enlarging.

The major environmental factors i. E. Temperature, radiation and humidity were given special consideration. Other factors to be controlled are;air movement and composition, soil temperature, plant nutrient and water quality.

DESIGN AND CONSTRUCTION

1) Large walk-in type Growth chambers :

The front view and interior view of one of the two walk-in type chambers, is shown in Fig.1 and Fig.2 respectively. The inside dimensions of these chambers are 2.70 m x 2.70 m x 2.25 m (height). The height of the lamp compartment is 31 cm. Walls, floor and roof are made of 10.20 cm thick thermocole sandwiched between 1.6 mm thick aluminum sheets. Artificial illumination has been achieved by a combination of 112 numbers of 40 W cool white fluorescent lamps, 8 numbers of 20 W fluorescent lamps and 15 numbers of 100 W incandescent lamps. The refrigeration load at peak period for each of these chambers was calculated to be 5.58 tonnes. A common refrigeration plant to serve both these units was installed. The temperature was controlled by a temperature controller and relative humidity was controlled by a humidistat. Atmospheric concentration of carbon dioxide was maintained with the help of an auxilliary air duct system in the air handling unit. The inside chamber temperature could be varied from 10 °C to 40 °C with 0.50 °C accuracy. The relative humidity could be varied from 40 per cent to 95 per cent with 4. 2 per cent accuracy.

2) Portable reach-in-type Growth Chamber:

A reach-in type growth chamber with 3.25 m x 0.81 x 1.10 m (height) plant growing area has been also designed and constructed (Fig.3). This chamber is useful for growing plants without entering the chamber. Three independent doors are provided for irrigating or for other measurements with the plants. An operator can stand outside and perform all operations without disturbing the inside conditions. This chamber is equipped with 36, 80 W fluorescent lamps and 6, 100 W incandescent lamps which provides 34.500 lux at 50 cm beiow the transparent ceiling. An axial flow blower of 17.2 m3/min capacity has been installed (Fig.3) at one end of the chamber to carry away the heat accumulated in the lamp-hoft. Air vents (5 cm x 10 cm) are provided for fresh air supply. Two room air conditioners of 1.5 tonne capacity each have been installed for temperature control. The inside temperature in this chamber can be controlled from 10°C to 40°C with + 0.5°C.

A few experiments on spectral characteristics of rice leaves and energy balance of rice crop canopies have been conducted inside walk-in type of growth chamber. Performance of these chambers was tested and they were found satisfactory for growing tropical crops like rice.

REFERENCES

l. Ashrae Guide and Data Book.1964. Chapter 11. Environmental Control for Animals and Plants. American Society of Heating Refrigerating and Air Conditioning Engineers Inc. New York USA.

2. Bailey W. A., R. J. Downs and H. H. Klueter.1964. Control of humidity in plant growth structures. ASAE Paper N° 64-306. 8 pp mimeo.

3. Hellmers H. and R. J. Downs.1967. Controlled environments for plant life research. ASHRAE Journal 9 (2): 37-41.

4. Klueter H. H., W. A. Bailey H. M. Cathey and D. T. Krizek.1967. Development of an experimental growth chamber system for studying effects of major environmental factors of plant growth. ASAE Paper 67-112 presented at the Annual Meeting of ASAE at Saskatoon, Saskatchewan, Canada.

5. Morse R. N. and L. T. Evans.1962. Design and development of CERES an Australian Phytotron. Jour. Agric. Eng. Res. 7 (2): 128-140.

6. Singh P. M.1969. Design of Environmental Control Chambers for Rice Growth Studies. Unpublished Ph. D. Thesis. Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur, India.

7. Vince D.1963. The plants, light requirements. Proceedings of the Symposium on Engineering Aspects of Environmental Control for Plant Growth. C. S. I. R. O. Australia.-

XXIV. THE USE OF GROWTH CHAMBERS IN ECOLOGICAL STUDIES OF THE CLIMATIC CONTROL OF PLANT DISTRIBUTION

Dr. F. I. Woodward Department of Biology, University of Lancaster, Lancaster, Great Britain.

In England the arctic-alpine plant species *Sedum rosea* has a lower altitudinal limit of 400 m, while the closely related lowland species *S. Telephium* has an upper altitudinal limit at the same altitude. The aim of this research has been to determine the effectiveness of competition in defining the altitudinal limits of the two *Sedum* species , and to investigate the implication of climate in this control.

In both field and growth chamber experiments seedling plants of *S. Rosea* and *S. Telephium* were grown in competition to quantify the competitive ability or aggressiveness of the two species under the different climatic conditions.

Field experiments have provided evidence of the changing competitive capacity of the two species over a range of altitude from 25 to 625 m (Woodward, 1973; Woodward and Pigott , 1975). Table 1 demonstrates that over a range of altitude from 25 to 625 m *S. Telephium* exhibits a significant reduction in growth with increasing altitude, and over this range the reduction is linearly correlated with changes in altitude. In constrast the growth of *S. Rosea* is very insensitive to changes in altitude. The effectiveness of competition in controlling the plant response was demonstrated by the significantly greater growth of both species when grown alone.

Table 1.1.1aximum plant cover (one growing season) of *S. Telephium* and *S. Rcsea* over a range of altitudes in Northern England.

Altitude m	*S. Telephium* cover dm2	*S. Rosea* cover dm2
25	0.242+ 0.044	0.030+ 0.013
120	0.179 + 0.031	0.042+ 0.013
315	0.129+ 0.039 0	028 + 0.011
455	0.074+ 0.023	0.028+ 0.009
530	0.048+ 0.014	0.028+ 0.010
550	0.036+ 0.009	0.024+ 0.008
625	0.019+ 0.0, 3	0.028 + C.004

95% confidence limits show..

That climate is the active component in the effect of altitude on competition appears likely from the manner in which the growth of *S. Telephium* declines linearly with increasing altitude, which suggests that the species is responding to a smooth gradient of climate with the changes in altitude.

The climatic conditions, in particular air temperature at plant height, irradiance and soil water potential, have been recorded over this range of altitude (Woodward, 1973; Woodward and Pigott, 1975). Air temperature falls at a rate of 0.67 °C per 100 m increase in altitude, and associated with the fall in temperature is a reduction in vapour pressure deficit and an increase in soil water potential. The integrated daily totals of irradiance also decrease with increasing altitude, a fact which can most easily be explained in terms of the increased cloud cover observed with increasing altitude in the mountains of Northern England. Windspeed was not measured, but as the maximum plant height was 10 cm above ground level it seems unlikely that differences between altitudes would have large and significant effects on plant growth.

A second field experiment demonstrated that the reduction or removal of both altitudinal and time differences in vapour pressure deficit, soil water potential and photoperiod by growing the plants in pots in wet tunnels and during the summer solstice, did not significantly affect the previously recorded growth responses of the two species at different altitudes, without the reduction of these climatic variables. Thus it appears likely that of the more obvious climatic variables, either temperature and/or irradiance control the competitive responses of the species.

At this stage field experimentation has provided evidence for the possible implication of temperature and/or irradiance in the control of the competitive responses of the species, but it can not simply separate the effects of temperature and irradiance on plant growth. Consequently a growth analysis experiment was designed for growth chambers, to determine the effect of differences in a single climatic variable, temperature, on the growth in competition of *S. Telephium* and *S. Rosea.*

The observed temperature lapse rate of 0.67°C/100 m indicates that even over the entire studied altitudinal range of 600 m the difference in mean temperature will be only 4.02°C, so if temperature is effective in determining the competitive response, then the magnitudes involved will be small.

Using temperature data obtained in the field two temperature treatments were designed for two growth chambers (manufactured by Fisons Scientific Apparatus Ltd, Loughborough, Leicestershire), and the environmental conditions are outlined in Table 2.

Table 2.Environmental conditions for growth chamber competition experiment.

Variable		Growth Chamber 1	Growth Chamber 2	Notes
Irradiance		65 to 85 Wm^{-2}	65 to 85 Wm^{-2}	400–700 nm waveband (fluorescent and incandescent light sources)
Photoperiod		16 hours	16 hours	
Temperature	Day	12.5°C ± 0.7°C	15.0°C ± 0.7°C	Temperature monitored at
	Night	5.0°C ± 0.5°C	5.0°C ± 0.5°C	plant level
Relative	Day	75% ± 10%	75% ± 10%	
Humidity	Night	80% ± 10%	80+ ± 10%	

Sample plants were harvested initially and then after 43 days when the outcome of competition was clear under both-temperature treatments.Table 3 compares the final dry weights of the two species under the two temperature conditions and these results are also compared with a similarly designed experiment in the field where the plants were grown at two different altitudes. The mean temperatures of the growth periods, in both the field and the growth chambers, are also compared.

Table 3.Final dry weight of *S.telephium* and *S.rosea* under four different experimental treatments.

	Growth Chamber 1	Growth Chamber 2	Field (490m)	Field (150m)	
Final dry	0.028 ± 0.006	0.095 ± 0.018	0.045 ± 0.006	0.073 ± 0.012	*S.telephium*
weight (g)	0.062 ± 0.009	0.053 ± 0.016	0.051 ± 0.011	0.038 ± 0.005	*S.rosea*
Mean temperature °C	10.0°C	11.7°C	11.5°C	13.7°C	

95% confidence limits quoted.

It may be seen that, in the growth chambers, a change in mean temperature of only 1.7°C (approximately equivalent to a 250 m change in altitude) is sufficient to cause a complete reversal in the outcome of competition between the two species, measured in terms of accumulated dry weight. Small differences in saturation deficit in the order of 0.5 mb/1.7°C change in temperature have not been eliminated, but it is unlikely that such small differences will have a large effect on the outcome (Hughes, 1959).

Table 3 indicates that on a mean temperature basis the reversal in the outcome of competition is likely to occur at a higher temperature in the field than in the growth chamber. This suggests that temperature alone may not entirely account for the results obtained in the field. Comparison of the specific leaf areas (SLA), the leaf area per unit of leaf dry weight, of plants grown in the growth chamber and the field (Table 4) suggests that differences in irradiance (with decreasing irradiance leading to an increase in SLA) may also be involved, although spectral or light quality effects can not be ruled out.

Table 4. SLA of plants of *S. telephium* and *S. rosea* grown in the field and in the growth chamber.

	Growth Chamber 1	Growth Chamber 2	Field (490 m)	Field (150m)
SLA	2.34 ± 0.25	2.69 ± 0.14	3.90 ± 0.23	3.63 ± 0.16 *S. telephium*
$dm^2 g^{-1}$	2.28 ± 0.15	2.81 ± 0.47	3.75 ± 0.41	3.39 ± 0.22 *S. rosea*
Mean temperature °C	10°C	11.7°C	11.5°C	13.7°C

95% confidence limits shown

Further experiments (Woodward, 1975) have shown that the growth of *S. Telephium* is more sensitive than *S. Rosea to* a reduction in irradiance, and this may prove to be a competitive advantage to *S. Rosea* in natural situations of low irradiance and so may account for the differences in the outcome of competition discussed above.

However, the important fact remains that the growth chamber has been able to demonstrate that very small changes ir. air temperature alone can to a large extent account for the results obtained in the field.

References

Hughes A. P.(1959). Plant growth in controlled environments as an adjunct to field studies. Experimental application and results. J. Agric. Sci. Camb., 53, 247.

Woodward F. I.(1973). The effect of climate in determining the altitudinal limits of certain plant species of northern England. Ph. D. Thesis, University of Lancaster.

Woodward F. I.(1975). The climatic control of the altitudinal distribution of *Sedum rosea (L)* scop and *S. TeZ. Ephium L.* II. The analysis of plant growth in controlled environments. New Phytol. 74, 335-348.

Woodward F. I. & Pigott C. D.(1975). The climatic control of the altitudinal distribution of *Sedum rosea (L.)* Scop. And *S. TeZephium* L. I. Field observations. New Phytol.74, 323-334.

XXV. AUTOMATED LIQUID CULTURE SYSTEM

ASHS -Growth Chamber Committee August 1976 (USA)

PURPOSE

This is a general description of a continuous circulation solution culture system which was developed by the Growth Chamber Committee of the American Society for Horticultural Science and patterned after systems commonly utilized in research laboratories in the Netherlands. The system automatically replenishes the solution as water is lost by evapo-transpiration, and continuously replaces solution in the system at a set rate to minimize the changes in H+ and nutrient ion concentrations.

The system has been designed to meet the following criteria :

a) Maintain a constant level of solution in the plant containers at all times.
b) Maintain the concentration of nutrient ions in the solution within 25% of the initial concentration.
c) Maintain pH within+0-5pH units of the established pH.
d) Is not overly wasteful of nutrient solution.
e)Simple in design so that it can be built at a reasonable cost and operated easily.
f)Constructed of materials that are readily available, are not phytotoxic, that do not require specialized tools for machining, and that do not encourage the growth of slime bacteria.

GENERAL DESCRIPTION

The system consists of the following parts which are illustrated and labeled in Figure 1.

1. A mixing chamber containing solution.
2. A solution pump with a manifold for distributing solution to twenty plant containers.
3. Twenty plant containers each with an internal drain tube.
4. A solution return manifold which collects the drainage solution from each of the twenty containers and returns it to the mixing chamber.
5. A control system consisting of a float, micro-switch and solenoid which allows solution to flow by gravity from an elevated reservoir as the level of the solution in the mixing chamber drops.
6. An elevated reservoir.

Solution is continuously pumped from the mixing chamber, through the distribution manifold and into the individual one-liter plant growth containers. The continuous addition of solution to the containers causes an equal amount of solution to continuously overflow into the internal drain tubes and then into the collection tubes under the containers, and through these tubes back to the mixing chamber. The continuous circulation of the solution through this pathway results in the aeration of the solution and the continuous mixing of the solution among the twenty containers.

As solution is removed from this closed system, either by leakage, evapo-transpiration, or for renewal of solution, the float in the mixing chamber will lower. When the float drops sufficiently to release the micro-switch arm, the switch closes, acti-

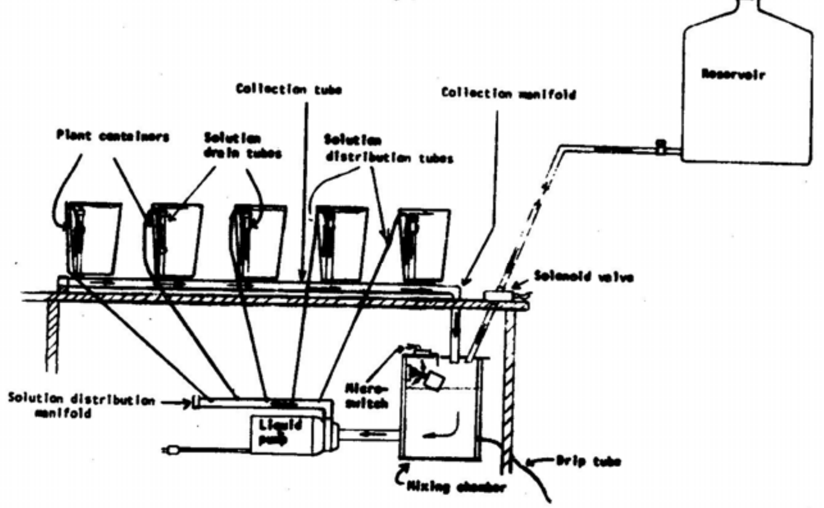


Figure 1. Diagram of solution culture system, showing relative placement of the different components of the system, and the direction of solution movement in the system.

vating the solenoid. Upon activation, the normally closed solenoid opens , allowing solution to flow from the reservoir to the mixing chamber.

To prevent H^+ and nutrient ion concentration changes in the solution as plants are growing, old solution is continuously removed from the mixing chamber at a controlled rate via a small capillary drain in the chamber. The rate is controlled by the length of this tube and the distance the end of the tube is below the level of the solution in the mixing chamber.

If specific details of the system are desired, contact :

Dr. T. W. Tibbitts
Department of Horticulture
University of Wisconsin
Madison WI 53706 USA

- o

XXVI. NEW LABORATORY MATERIALS I

We publish below some information received about new material liable to interest our readers. More detailed information can be obtained by writing directly to the manufacturers whose addresses are given below ;

1)Agricultural Growth Industries Inc.

Address: 2326 Bisso Lane, Suite 6, Concord C. A.94520 USA Manufacture of controlled environment growth chambers for the production of hydroponic grass:
Model 6 A 180 with 42 trays, producing 180 pounds per day after 7 days
Model 12 A 360 with 84 trays producing 360 pounds per day after 7 days
Model 24 A 720 with 168 trays producing 720 pounds per day after 7 days.

2)Fisons Scientific Apparatus

Address: Bishop Meadow Road, Longborough-Leicestershire LE II ORG, UK.

Representative in France : Mr. Baule c/O OSI (te1.533 74 87)

A new series of air conditioned growth cabinets (series III) supplementing

the five existing ones has been put on the market. Ascending air circulation contrary to the horizontal circulation in Series V. Temperature limits : 0 tO 45°C. with humidity control and 40.000 lux lighting. 3 models 600 (a3 (i.2 x 0.6 x 0.82 high) capacity 600 liters 2350 G3 (1.8 x 1.0 x 1.3 high) capacity liters ; 3600 G3 (2.4 x 1.0 x 1.5 high) ClUiTY 3600 liters.
Lighting : fluorescent tubes or incandescent lamps
Optional : temperature control of the lighting panel as well as humidity in the cabinets.

3)Scientific Systems Corporation

Address: 9020 South Choctaw, Baton Rouge, LA 70815 USA

Construction of : Controlled environment chambers: 23 standard models covering **6** different temperature series with an absolute minimum of -120°C.

Twin incubators, 5 series depending upon destination
Light incubators with vertical lighting, 3 series depending upon volume and intensity of lighting
Air conditioned growth cabinets from 20 to 68 cubic feet.
Sterile chambers, 3 series depending upon dimensions.
Culture chambers with T°, humidity and CO_2 control and recording of factors.

4)Techtum Instrument

Address : Kungsgatan 145-S 902 45 UMEA, Sweden

Q "quanta Spectrometer" for measuring radiations between 400 and 740 nm. has been put on the market. Model QSM 2500 measures the number of quantas by m2 per s and my nm (O2 m-2 s-1 nm-1), calibrated in absolute unity avoiding any calculations. An integrator can also be used to sum up the radiations in the interval of the chosen radiations.

- o -

I XXVII. CLIMATE LABORATORY NEWSLETTER N°6 OCTOBER 1975

Below we give summary of this New Zealand journal.

1) CO, System .$0O_2$ levels may fall during the photoperiod to 150 ppm (cf ambient at 320-350 ppm) especially in experiments where a large number of actively growing plants are placed in a single climate room. Experimenters working with large plant loads should consider maintaining CO_2 at ambient levels.

2)Climate and Climate Rooms: Many experiments wishing to simulate New Zealand temperature conditions are using the average daily maximum for their upper temperature and a night temperature 5°C lower, so arriving at a night/day average temperature of between 3 and 5°C above those in the warmest places in New Zealand. The N. Z. Meteorological Service publication "Summaries of Climatological Observations to 1970 " gives monthly mean temperature throughout New Zealand as well as maxima and minima.

3)Climate room space.

Lead time: The average time between submitting the first proposal and entering the climate rooms is 3 months.

All project proposals should be finalised lmonth before the experiment is due to begin.

Room Allocation Committee: This committee is responsible for recommending allocation of space between major user groups. It meets every May and November to review work carried out over the preceding 6 months and programs allocation of space for the next 6-12 month period.

Summary of Climate Room Use for 30 April- 26 Dec.1975 (Room Weeks)

		Use	Allocation	No. Of Expts
DSIR		102	84	7
Universities		111	84	6
F R I		156	84	13
M A F		90	84	3
MWD		17	0	1
P P **D**	Res	116	172	
	CRS	55	172	11
	Maintenance	120	120	
Unused		25		
TOTAL		792	792	41

Actual Room-use is approaching the limit of the Climate Laboratory.

REVIEW OF THE FIRST 5 YEARS OF CLIMATE ROOM OPERATION

The Climate Laboratory has been in operation for five years. Over this period thirtynine plant species and two animal species have been used in 132 experiments covering several disciplines.

Classification of Climate room-use according to crop types
(Period 1971-75)

	No. Of species	Room use
Trees and shrubs	9	23
Grain and process crops	14	20
Weeds	1	2
Forage crops	3	2
Pasture	11	39
Turf	**1**	**1**
Other	.2.	1
	41	
		100

Classification of Climate room-use according to disciplines (Period 1971-75)

		Room use %
Physiology	general	51
	water relations	4
	low temperature	5
	frosting	2
	developmental	5
Plant biochemistry		4
Plant pathology		22
Plant breeding		2
Soils		2
Entomology		1
Climate Room Systems		2
		100

The yearly use of Climate Rooms (Room months)

	1971	1972	1973	1974	1975	Allocation 1975[x]
DSIR			23	18	32	36
M A F			38	14	32	36
Universities			27	53	40	36
Forestry	7	30	64	54	51	36
Plant Physiology Division						
Research	109	46	35	30	43	72
CRS	7	22	21	30	17	72
Other				2	5	0
Total	123	98	208	201	220	288
Number of experiments	12	19	23	32	43	

Includes maintenance between experiments.

NB: 144 Room-months are allocated to outside users, however, an average of 140 Room-months have been used over last 3 years.

Two trends have become apparent over the past 3 years, viz . Annual room use has stabilised at approximately 210 room months and experiments have become shoiter. In 1973 the average experiment used 9 room months but by 1975 this had decreased to 5 room months.

4)Accommodation: Approval has been given to build a 65 sq m. Two-bedroom housing unit for Climate Room visitors accommodation. Building will commence early next year.

5)TECHNICAL SYSTEMS

Nutrient System: A flow detector has teen designed, built and installed in the A & B nutrient lines. The new detectors have eliminated the less reliable mechanical system previously operating and will detect flows from 1-20 litres/min with visual display of flow rate at the Central Control Board. These detectors allow routine checks to ensure that plants are being fed nutrients.

6) Chiller System : One of the two original eight-ton chillers is being replaced. The chillers have a life expectancy about five years and extensive mechanical wear have made repairs costly. However it will be used to supply spare parts to the remaining unit. The new chiller has a 12 ton capacity. The remaining eight-ton unit is scheduled for replacement in late 1976.

Lighting : The new GEC Duraglow reflectors are being fitted into all rooms to replace the old Sylvania Vanguard reflectors. The new reflectors can be adjusted to focus or disperse light enabling intensity to be more easily controlled and horizontal light gradients at plant growing height to be further reduced.

Supplementary low intensity lamps capable of extending the photoperiod while maintaining low photosynthesis rates, have been fitted to most rooms. The remaining rooms will be completed when cable supplies arrive.

A new high pressure sodium vapour lamp with high luminous efficiency has arrived and will be tested after January 1976.

An improved device for cleaning the lamp-loft glass has been constructed. This should reduce the cleaning time required from 3 to 1 day/week.

8) Current projects

R. M. Davison. Flowering of Chinese gosseberry (Kiwi Fruit)

A. C. P. Cnu. Effects of water stress on leaf extension growth in Prairie grass.

N. J. Withers. Effects of water stress on development and seed yield of sofflower.

R. Martin. Water relations in wheat

A. G. Spiers. A study of the temperature conditions necessary for the infection of poplars by Poplar rust.

D. Cohen, K. S. Milne and C. R. Slack. Heat therapy of virus infected plants. M.

F. Beardsell. The effects of handling on plant growth and leaf water potential. M.

A. Eagles. The growth of the mexican maize family cachuacinthe.

E. A. Edge and A. K. Hardacre. The evaluation of nutrients/potting mix combinations commonly used in the climate laboratory.

P. G. Roughan, A. K. Hardacre and R. M. Haslemore. The effect of pot size on carbohydrate accumulation in leaves of two panaccid grasses and tomato.

I. R. Brooking and H. A. Eagles. Heritability of cool-tolerance for pollen development in sorghum.

XXVII bis. CLIMATE LABORATORY NEWSLETTER N 7 JULY 1976 [

Below we give summary of this New Zealand journal :

1)Dr. Yan Warrington after spending 18 months in USA return back as Climate Room Coordinator.

2)Controlled Environment room use

The total occupancy of the Lab was 90% of the maximum ; the remainder being accounted for by reduced use over the Xmas-New Year period.

Summary of use : 1 Nov. 1975 to 1 May 1976

	USE	ALLOCATION	No. OF EXPTS
	Room weeks		
DSIR	131	78	3
M A F	63	78	2
UNIVERSITIES	35	78	1
FRI	84	78	5
M W D	(96)		2
MAINTENANCE (15%)	47		
TOTAL EXTERNAL	360	312	13
PPD RES	157	156	10
CRS	18	156	2
MAINTENANCE (15%)	26		
TOTAL P P D	201	312	12
GRAND TOTAL	561	624	25

Un-used: 63 Room wks (includes Xmas-New Year period)
Occupancy : 90%

3)ACCOMODATION

The overnight flat is now complete and all services have been supplied. The total cost for the facilities, not including furnishings was $14.000.

There will be a charge for use of the accommodation . ($ 5 per person per night , maxi, $ 10 per night for the entire flit which will sleep 4). The flat will be avaiable as from 1 August. The rules for the facilities have been circulated and are included in the Newsletter.

4) CONTROLLED LNVIRONMENT CABINET

A considerable effort over recent morth4 has gone towards performance testing of a Temperzone Ltd. reach-in controlled environment cabinet. The cabinet design was originated at Plant Physiology Division and is manufactured under licence from the Inventions Development Authority. A summary of the test results is presented below.

Summary

1. Energy flux densities of 190 W/m2 PAR and greater were measured at bench height. This is acceptable. Evenness of light distribution was good.

2. Cabinet will control air temperatures satisfactorily at levels from °C to 40 °C to an accuracy of + 0.5 C.

3. Humidity control is satisfactory at temperatures between 10°C and °C with lower humidity limits between 60% and 30% RH over that temperature range. Partial RH control is practical over 3°C to 40°C temperature range but absolute control is limited by dehumidifier performance.

5)ROOT WASHING FACILITIES

To separate plant roots from the various growing media used in the Climate Lab. We now have an efficient root washing unit. This consists of a 3.8 m long stainless steel trough and two hand held high-pressure "Jetspray" (Titchener-Noton Industries, Auckland) hose nozzles which are the key to the systems effectiveness.

6) CURRENT PROJECTS

J. De Ruiter, A. O. Taylor. A study of the effect of photoperiod and temperature on floral initiation and growth of cool season forage legumes.

H. A. Eagles. Protein content in forage oats.

J. B. Taylor. The relationship of the pathogenicity of 20 Basidiomycete fungi to temperature.

C. G. Janson. Climatic effects on lucerne under simulated grazing.

N. J. Withers. A study of the effect of water stress on the seed yield of *Lupinus albus.*

G. Sheath. Regrowth studies of *Lotus pedunculatus.*

I. M. Ritchie. Effects of temperature and defoliation regimes on the growth and yield of newly released pasture species.

P. D. Gadgil. The pathogenicity of *Naemacyclus minor* on *Pinus radiate.*

M. I. Menzies. Effect of pretreatment conditions on the frost damage of radiata pine seedlings.

M. I. Menzies. Seasonal variation in the frost tolerance of three Eucalyptus species *(Paatigata, Regnans* and *Saligna).*

M. I. Menzies. Evaluation of frost resistance of 23 polycross families of *Pinus radiate.*

M. E. Dutch. The effects of variation in temperature, light intensity and moisture stress on the growth of seedlings of hard beech *(Notholagus truncate).*

T. J. Warrington. Comparisons of plant growth under light of similar quantum flux densities from various lamp types (incl. High pressure sodium lamps).

A. Chu. Effects of water stress on two cultivars of ryegrass.

R. Cross and J. M. Mc Ewan. Nitrogen metabolism and uptake in Karamu wheat and related genotypes.

J. Mann. Environmental effects on the growth and alkaloid production of *Solanum aviculare* and *Solanum Zaciniatum.*

7)CLIMATE LABORATORY LIGHTING SYSTEMS

A discussion of their development and use I. J. Warrington, Biological Coordinator, Climate Laboratory.

Editor's Note. We give to our readers just a very short summary of this discussion. Those who want have more information please write to: I. J. Warringto'l. DSIR. Plant Physiology Division•Private Bag. Palmerston North. New Zeland.

Artificial lighting systems simulating sunlight in intensity and spectral balance over the photosynthetically active (400-700 nm) and near-infrared (700-1000 nm) regions of the spectrum, have been the goal of controlled environment workers for many years. Many different lamp types have been tested and used . In this article the lighting systems used in the Climate Laboratory are discussed.

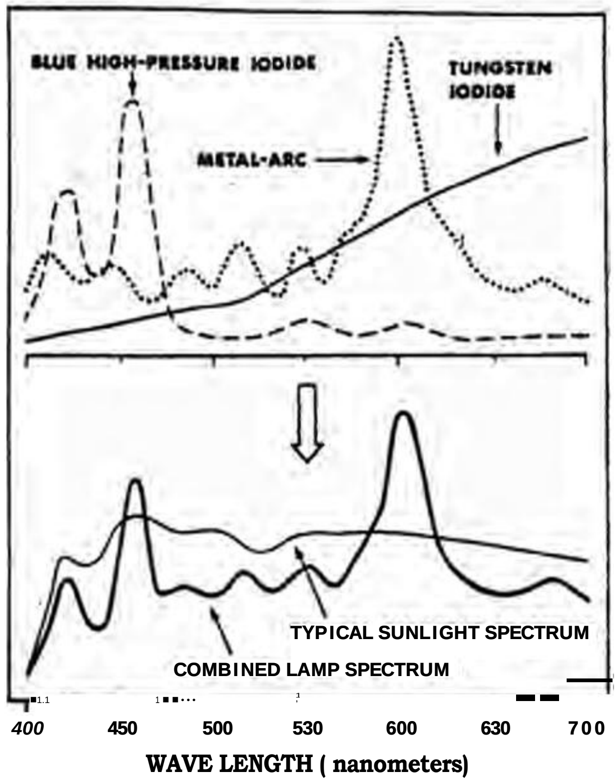
Standard Lighting Systems

The standard lamp combination at present used in the CE rooms is: four 1000 W Philips Tungsten Iodide lamps. With new lamps this combination produces an irradiance of approximately 180 Wm^{-2} (P. A. R.) (equivalent to 550-600 FE mr-2 sec^{-1} or 5000 ft. C.) at standard plant pot height 2.5 meters below the thermal barrier.

Use of additional and larger lamps has produced higher irradiances. Six 1500 W Sylvania Metalarc plus nine 1000 W Philips tungsten iodide produced over 400 Wm^{-2} PAR (or 1800-2000 AIE $m^{-2}sec^{-1}$) at 2.5 m below the thermal barrier. Peak sunlight values (i. E. Midday, mid-summer) are approximately in the range of these latter values.

Experience has shown that lamp ageing is not a significant problem. Lamps are normally used for 2 years and over this period drop in intensity from around 160-180 Wm^{-2} P, A, R, to 130-140 Wm^{-2} P, A, R. Rooms with older lamps are used for lower light intensity studies.

Although HID lamps are point source lamps many of the problems of "hot spots" in the plant growth chamber can be overcome by careful placement of lamps, use of suitable reflectors and use of mirrored walls. The recently developed General Electric "Duraglow" reflector (a fluted reflector with an adjustable lamp holder) has been found very satisfactory for our use. By adjusting the position and angle of tilt of each lamp on the lighting rig, light uniformity better than 5% can be obtained at plant growing height on a 2 x 2 m horizontal platform (20 cm grid).



. **Combination of HID and incandescent lamps allows close simulation of sunlight and provides the ability to change or modify spectral composition.**

XXVIII. LIST OF NEW BOOKS

V. A. Alexeyev. Light climate of Forest (in Russian) 1975 227 pages Ed. Ac. Sci. Of USSR.

A. Atanasov. Investigations on organogenetical abilities of tissue and cellular cultures of Sugar Beet with a view to use them in genetics and heeding (in Bulgarian) 1976, 28 pp. Ed. Ac. Sc.

G. W. Arnold and C. T. De Wit. Critical evaluation of systems analysis in ecosystems research and management 1975. 114 p. Ed. Centre for Agric. Ptblishing Wageningen . The Netherlands.

M. Barbier. Introduction a l'ecologie chimique. Collection d'ecologie.1976, 132 pp. Ed. Masson Paris.69 F. F.

D. J. F. Bowling. Uptake of ions by Plant Roots.1976. 222 p. Ed. Chapman and Hall. AC 6.50

J. P. Cooper . Photosynthesis and productivity in different environments.1975. 715 p. Ed. Cambridge University Press (UK). . F 22.

Economie d'energie en horticulture.1975. 172 pp.40 F. F. Ed. P H M , 59 rue du Faubourg Poissonniere, 75009-Paris.

0. H. Frankel et J. G. Hawkes. Crop genetic resources for today and tomorrow. 1975.492 p. Ed. Cambridge University Press (UK). cfl$

D. Gates and R. Schmerl. Perspectives of biophysical ecology.1975.609 p. Ed. Springer Verlag. US $ 36.70.

Gel et Recolte. Travaux de l'Institut de Meteorologie experimentale (en Russe). Edition llygrometeo. Moscou 1975. N° 4 (48).208 p.

Z. Guminska. The hydroponic culture of plants (Translated from Polish) I976. Ed. USD of Commerce. National Technical Information Service. Springfield Va 22161. USA.

J. Ives and R. Barry. Arctic and A4pine environments .1974.999 p. Ed. Methuen and Co. London (UK) of 35.

W. Larcher. Physiological plant ecology.1975.252 p. Ed. Springer Verlag US $ 18.90

V. M. Leman. Cours de culture sous eclairage artificiel (en Russe) 2e edition Moscou. Vischaia Chkola 1976. 272 p.

G. Long. Diagnostic phyto-ecologique et amenagement du territoire. Vol. II. Application du diagnostic phyto-ecologique.1975. 232 p. Ed. Masson Paris. 100 F. F.

E. Madsen. Effect of CO_2 concentration on morphological, histological, cytological and physiological processes in Tomato Plants.1976. Ed. De studerendes boghandel. Thorvaldsensvej 40, DK 1871 Copenhagen V. Danemark. apprex. US $ 5.50

P. S. Nutman. Symbiotic nitrogen fixation in plants.1976. 584 p. Ed. Cambridge University Press (UK) cif 22.

Photosynthese et production vegetale. Collection formation permanente en ecologie et biologie.1975. 284 p. Ed. Gauthier-Villars Paris. 75 F F.

Physiological Plant Pathology. Encyclopedia of Plant Physiology vol.4 1976. 840 p. Ed. Springer Verlag. US $ 79.60.

A. Poljakoff-Mayber and J. Gale. Plants in saline environments.1975. 213 p. Ed. Springer Verlag US $ 31.30.

Proceedings of the 3rd MPP Meeting Izmir october 13-17 1975. Edited by Y. Vardar. Ege University . Bomova Izmir Turkey 1976, 112 pp.

Questions agricoles dans l'exploitation de la region Nord de l'Oli (en Russe). Travaux du Research Institute of Agriculture of Oural North. N° I8.1975. 190 pages.

R. Rieger and all. Glossary of Genetics and Cytogenetics .1976. 650 p. Ed. Springer Verlag. US $ 14.80.

J. Sholto Douglas. Hydroponics: The Bengal System with notes on other Methods of Soilless Cultivation.1975. 202 p. Ed. Oxford University Press * 1.95.

L. P. Smith. Methods in agricultural meterology.1975.210 p. Ed. Elsevier-Netherlands. US $ 31.25.

P. T. Stol. A contribution to theory and practice of non-linear parameter optimization. 1975.197 p. Ed. Centre f. Agric. Publishing Wageningen. The Netherlands.

Technical communications of ISHS. Copies can be ordered by the Secretariat of the Society : Bezuidenhoutseweg 73 . The Hague. Netherlands.

N° 44. IX. International Symposium on fruit Tree Virus Diseases East Mailing July 1973. Print in february 1975. pp.267.

N° 47. Second International Symposium on Flower Bulbs, Littlehampton. Skegness. April 1974. Printed in june 1975. Pp.426.

N° 48. Symposium on Plum Genetics and Plum Breeding Bordeaux august 1973. Printed in July 1975. 125 pp.

N° 49. Third African Symposium on Horticultural Crops, Nairobi September 1973. Printed in July 1975. pp.306.

N° 50. Symposium on Peat in Horticulture. Noordwijk. April 1975. printed in May 1975. pp•171.

N° 51. Symposium on Protected Cultivation of Flowers and Vegetables. ScheVeningen. May 1975. Printed in August 1975. pp.361.

N° 52. Timing of Field production of Vegetable Crops. Ohrid june 1973. Printed in december 1975. pp.263.

N° 54. Propagation in Arboriculture. Krogerup-August 1975. Printed in december 1975. pp.145.

Utilisation des solutions nutritives dans les cultures de plantes en pot. Expose de la journee du 27 fevrier 1976 du CNRA de Versailles. Ed. CNIH.10 rue du Seminaire BP 309. 94152. Rungis Cedex . France.

H. Wheeler. Plant pathogenesis.1975. 106 p. Ed. Springer Verlag. US $ 16.

- o -

I XXIV. ARTICLES IN PRINT 1

Alberte S., L. Fiscus and A. W. Naylor. The effects of water stress on the development of the photosynthetic apparatus in greening leaves. *Plant Physiol.55:* 317-321.1975.

Alberte S. and A. W. Naylor. The role of cytokinins in chloroplast lamellar development *Plant Physiol.* 55: 1079-1081.1975.

J. Ansiaux. Interactions entre 1'alimentation hydrique et l'alimentation minerale de la plante.1975. *Annales de Dembloux* n°2 , pp.89-104.

E. Berninger. Le chauffage des serres florales.1975. *Bulletin n°3 de la station de l'INRA. La Gaudine.83600. Frejus. France.*

N. De Bilderling. Rale des phytotrons dans l'industrialisation de la culture protegee. 1975. *Annales de Gembloux* n° 3, . P.155-172.

D. Blanc. Evolution des caracCeres chimiques des sols en cultures protegees.1975. *Annales de Gembloux N°2 ,* pp.47-57.

F. Blondon.1975. Les exigences pour la floraison de trois lignees de *Vicia faba L.(Feverole). C. R. Acad. Agri.* , 61, (3 decembre 1975).

F. Blondon, et Gallais A.1976. Influence de la temperature, de la valeur de l'eclairement et de la photoperiode sur le developpement floral de quatre genotypes de Mais. *Ann. Amelior. Plantes,* 26 (2), 19 pages.

F. Blondon, Jacques M., Jacques R. et Mousseau M.1976. The combined action of light and temperature on development: some examples analysed in a phytotron. In : *" Environmental effects on crop physiology* ". Proceedings of the 5th Ashton Symposium Academic Press Publishers.

Blum U. and M. Letchworth. Effects of 0_3 on Nitrogen Fixation in Ladino Clover. *Annual Report to EPA.* 1975. 22 pp.

Blum U. and D. T. Tingey.1976. A study of the potential ways by which ozone could reduce root growth and nodulation of soybeans. *Jour. E5wiron. Qual.*

J. Bolyn. La croissance des plantes en milieux salins.1975. *AnnaZes de Gembloux n 2* pp.105-113.

M. De Boodt. Caracteres physiques et disponibilite en eau des substrats.1975. *Annales de Gembloux n° 2* pp.59-71.

Bourque D. P., P. N. McMillan , W. J. Cligenpeel, and A. W. Naylor. Untrastructural effects of water stres on chloroplast development in jack bean *(Canavalia ensiformis L. DC). Flant Physiol.* 56: 160-163.1975.

J. Van Bragt and al. Rooting of shoot cuttings of ornamental shrubs after immersion in auxin-containing solutions.1976. *Scientia Horticultural* 4, 91-94.

J. Van Bragt and K. J. Van Ast. Substitution of the cold requirement of tulip cv "Apeldoorn" by GA_3.1976. *Scientia Horticultural* 4: 117-122.

Bre M. H., J. Diamond et R. Jacques.1975. Factors mediating the vitamin B_{12} requirement of *Euglena. J. Protozool.22, 432 _434.*

Brulfert J., Guerrier d. et Queiroz 0.1975. Photoperiodism and enzyme activity;kinetic and rhythmic characteristics of photoperiodic induction of CAM. P1anta , 125, 33-44.

W. R. Burton and al. Hotpot: experiments with soil sealed plastics structures.1976. *Plasticulture* N°30, pp.33-41.

M. K. V. Carr and G. M. Milbourn. Maize:climatic and physiological factors limiting yield. 1976 Span.19, 2 p.65-67.

Chaillou S., Blondon F. et Scheidecker D.1976. Contribution a l'etude de l'action d'une temperature basse sur la croissance et l'alimentation minerale d'un hybride pricoce de Mars. *C. R. Acad. Agric. (12 mai* Z976).

Chlyah A. et Tran Thanh Van M.1975. Differencial reactivity in epidermal cells of *Begonia rex* excised and grown in *vitro. Physiol_Plant.,* 35, 16-20.

Chlyah H., Tran Thanh Van M. et Demarly Y.1975. Distribution pattern of cell division centers on the epidermis of stem segments of *Torenia fournieri* during de *novo* buds formation . Plant *Physiol.* 56, 28-33.

Chung, Hsu-Ho and P.J. Kramer. Absorption of water and 32P through suberized and unsuberized roots of loblolly-pine. Can. J. For. Res. Vol 5 2:229-235. 1975.

Cooper A. J. The nutrient-film technique of crop production *1976. Plasticulture* march n°29 pp.29-37.

Cosson L. et Valliant J. Ch.1976. Les alcaloides tropaniques *des* feuilles du *Duboisia myoporoides* neoealedonien. *Phytochemistry.*

Duda M. Variations saisonnieres de la teneur en chlorophylles de quelques especes de l'ecosysteme forestier (en Tcheque)1976. *Biologia* (Bratislava), 31, 4, 233-240.

Farmer R. E., Jr. Growth and assimilation rate of juvenile Northern red oak : Effects of light and temperature. *For. Sci.* 2 : 373-381. 1975.

Folley R. R. W. Science, economics and the future in a context of horticulture.1975. *Horticultural Abstracts* vol.45 n°8, p.477-483.

Folley R. R. W. The social factor in horticultural production 1976. Span 19, 2, p.64.

Forester R. L. and E. Echandi.1975. Influence of calcium nutrition on bacterial canker of resistant and susceptible Lycopersicon *sp. Phytophat.* 65 : 84-85.

Good R. E. and N. F. Good. Growth characteristics of two populations of *Pinus rigida Mill.* From the pine barrens of New Jersey. *Ecology* 56 : 1215-1220.1975.

Gresham C. A., T. R. Sinclair and J. E. Wuenscher. A ventilated diffusion porometer for measurement of the stomatal resistance of pine fascicles. *Photosynthetica* 9 (1), 72-77, 1975.

Hasegawa K. and T. Hashimoto. Variation of abscisic acid and Batatasin Content in Yam Bulbils. Effects of stratification and Light Exposure. *Journ. Exp. Botany* 1975, vol.26 , n°94 pp.757-764.

Heck W. W. and J. A. Dunning. Effect of SO_2 and/or O_3 on Several Oat Varieties. *Annual Report to EPA.* 1975, 80 pp.

Hesketh J. D., H. Hellmers, and J. N. Jenkins. Temperature control of leaf shape in the Okra cotton. *Cotton Grow. Rev.* 52 , 59-61, 1975.

Hesketh J. D., H. C. Lane, R. S. Alberte and S. Fox. Earliness factors in cotton : new comparisons among genotypes. *Cotton Grow. Rev.52,* 126-135.1975.

Heth D. and P. J . Kramer. Drought tolerance of pine seedlings under various climatic conditions. *For. Sci.* Vol.21, 72-82.1975.

Hofstra G. and J. D. Kesketh. The effects of temperature and CO_2 enrichment on photosynthesis in soybean. In : *Environmental and Biological Control of Photosynthesis. Edited by R. Marcelle.* Dr. W. Junk b v., Publishers, The Hague, 1975.

Huxley P. A. Agricultural re-education? 1976. Span 19, 2, p.8U.

Jeffs P. W. and J. D. Scharver. 13 - Hydroxystilopine. Structure and synthesis. *J. Org. Chem.* vol.40, 644-647, 1975.

Jerebzoff-Quintin S., S. Jerebzoff et R. Jacques.1975. Carotenogenese et rythme endogene de sporulation chez le *Leptosphaeria nrichottii (West).* Sacc. I. Action creclairements monochromatiques de la diphenylamine, de l'antimycine A sur)'evolution de la carotenogenese. *Physio1.114g.* 13, 55-67.

Laberche J. C. Problems of irrigation in greenhouses.1976. *Plasticulture.* n° 30, pp.43-55.

Larpent J. P. , R. Jacques , J. Quennemet et R. Moneger.1976. Qualite spectrale de la lumiere et morphogenese *du* thalle chez le *Draparnaldia mutabilis (Roth) Cederg. Bull. Soc. Phycol.* 21, 49.55.

Larpent-Gourgaud M., J. P. Larpent et R. Jacques.1974. Effet du phytochrome sur le developpement des protonemas de Bryophytes. *Soc. Bot. Fr., Coll. Bryologie,* 121, 153-160.

Luciani F. , L. Germaneau and Cl. Ch. Mathon. Daylength reactions of herbaceous an suffrutescent wild Phanerogams in Mediterranean latitudes.1976. Communication to 7th. Int. Congress on Photobiology. Rome 29 august-3 september.

Marcotte J. L., et Tram Thanh Van M.1975. Determination du bilan photosynthetique de *Cymbidium hawtescans* A des stades differents de developpement en fonction de la temperature et du degre hygrometrique. *Quaterly Bull. Fac. Sci. Vniv. Teheran,* 7, 1-7.

Marty J. Essai *de* cultures florales a temperatures nocturnes reduites. 1976. P. H. M. fevrier , pp.29-33.

Meheut G., M. Ducher et 0. Michaux.1976-Description d'un ensemble de chambres conditionnees en temperature et lumiere pour les etudes eicophysiologie vigetale:premiers resultats obtenus avec la Ehodophycee Acrochaetium sp. *Sco. Phycol. De France,* Bull. n°21, 12-17.

Mendoza H. A. and F. L. Haynes. Genetics of Actoperiodic behavior in tuber bearing. Solanum. I. Variability for photoperiodic reaction among diploid and tetraploid potato clones from three taxonomic groups. *Am. Potato Journ.* 1975.

Mendoza H. A. and R. L. Haynes. Genetics of photoperiodic behavior in tuber bearing Solanum. II. Inheritance of tuber initiation as influenced by photoperiod. *Am. Potato Journ.* 1975.

Minohara Y. The Status of Agricultural utilization of thermal Drainage in Japan.1976 march. Bio-Environment Laboratory Abiko city, Chiba-pref. Japan.

Monard J. F.1976. Period/cite journaliere du debit de l'exsudation caulinaire chez le *Lycopersicum racemigerum (LANGE). C. R. Acad. Sc. Paris* 282, 61-64.

Monard J. F.1976. Variations au cours du cycle journalier de la composition mine-rale de l'exsudat caulinaire chez le *Lycopersicum racemigerum (LANGE). C. R. Acad. Sc. Paris.*

Mous:;eau M. et Louason G.1976. Action de la photoperiode sur la respiration nocturne. Cas dune plante de jours courts, le *Chenopodium polyspermum L. C. R. Acad. Sc. Paris* 282, 719-722.

Nguyen J.1975. Determination in vivo des variations du catabolisme purique en fonction des duries d'obscurite ou de lumiere, dans les cotyledons du *Aarbitis* nil *Chois. C. N. Acad. Sc.* 281, 1709-1712.

Nowakoswki W. and al. Utilisation de l'energie solaire dans la productivite photosynthetique au cours *de* quatre phases vegetatives de differences varietes du *Triticum durum. L975. Acta Agrobotanica* vol. 18 n° 2, p.197-204.

Paris M., Boucher *F.* et Cosson L.1975. Importance des composes propyliques dans le *Cannabis* originaire d'Afrique du Sud. *Pl. M4dic. Phytoth.* 9, 136-139.

Paris M., Boucher F. et Cosson L.1975. The constituents of *Cannabis sativa* pollen. *Econ. Bot.* 29, 245-252.

Patterson D. T. Photosynthetic acclimation to irradiance in *Celastrvs orbiculatus Thunb. Photosynthetica* 9 (2) , 140-144.1975.

Patterson D. T. and J. L. Hite. A CO monitoring and control system for plant growth chamber;. *T"Le Ohio Journal of Sci.* 74 (4) , 190, july 1975.

Peterson K. M. and W. D. Billings. Carbon dioxide flux from tundra soils and vegetation as related to temperature at barrow, Alaska. *The American Midland Naturalist.* vol.94, pp.88-98, 1975.

Pierik R. L. M. and H. H. M. Steegmans. Freesia plantlets from flower-buds cultivated in *vitro.* 1975. *Neth. J. Agric. Sci.* 23, 334-337.

Queiroz 0. 1975. Rhythmical characteristics at different levels of CAM regulation : physiological and adaptive significance . In : *Environmental and Biological Control of Photosynthesis R. Marcelie Ed., Junk,* 357-368.

Raper C. D., Jr. Factors affecting the development of flue-cured tobacco grown in artificial environments : Growth responses to light schedules. *Tobacco* 177, 37-40, 1975.

Raper C. D., W. T. Smith and R. J. Downs. Factors affecting the development of flue-cured tobacco grown in artificial environments: Growth responses to light schedules. *Tob. Sci.* XIX, 22-25, 1975.

Raper C. D. and W. T. Smith. Factors affecting the development of flue-cured tobacco grown in artificial environments. V. Effects of humidity and nitrogen nutrition. *Agron. Journ.* 67 , 307-312, 1975.

Raper C. D., Jr. J. F. Thomas, M. Wann and I. K-York. 1975. Temperatures in early post-trans-
plant growth : Influence on leaf and floral initiation in tobacco. *C:' op Science* 15.

Seidlova F. Growth correlatives and RNA synthesis in Different Ponts of the shoot apical meristem of *Chenopodium rubrum L.* Induced to flowering. 1976. *Biologia Plantarwn* 18 (1) , 19.25.

Sine L. R6flexions actuelles sur la connaissance des conditions d'humidit6 des sols. 1975. *Annales de Gembloux* N°2, pp.73-88.

Smith A. P. Altitudinal seed ecotypes in the Venezuelan Andes. *Amer. Wdl. Nat.* 94, 247-250.1975.

Sotta B. et Miginiac E.1975. Influence des racines et d'une cytokinine sur la wise a fleurs d'une plants de jours courts, le *Chenopodium polyspermum. C. R. Ac. Sc. Paris* 281, 37-40.

Tcha K. H., Jacques R. et Jacques M.1976. Spectre d'action de la lumiere sur l'induction florale du *Calamintha officinalis ssp. Nepetotdes* et role du phytochrome. *C. R. Acad. Sc. Paris*

Teltscherova L. and D. Pleskotova. Nucleic acid synthesis and effect of glucose on its kinetics in cotyledons of *Chenopodium rubrum L.* during Photoperiodic Induction 1976. *Biologia Plantar um* 18 (1) , 50-57.

Thomas J. F., C. E. Anderson , C. D. Raper Jr. and R. J. Downs.1975. Time of floral initiation in tobacco as a function of temperature and photoperiod. *Canadian Journal of Botany* 53, 1400-1410.

Thomas J. F., C. D. Raper, Jr, C. E. Anderson and R. J. Downs. 1975. Growth of young tobacco plants ris affected by carbon dioxide and nutrient variables. *Agronomy Journal* 67 , 686689.

Thomas J. F. and C. D. Raper, Jr.1975. Seed germinability as affected by the environmental temperature of the mother plant. *Tobacco Science* 19, 104-109.

Thomas J. A. F.1975. Growth of young tc. Banco plants in controlled environments. *Diss. Abst.* 35 (10) , 4783-B.

Thomas J. F. and C. D. Raper Jr.1975. Differences in progeny of tobacco due to temperature treatment of the mother *plant. Tobacco Science* 19, 37-41.

Thorp J. H. and G. T. Barthalmus. Effects of crowding on growth rate and *symbiosis* in green hydra. *Ecology* 56, 206-212.1975.

Tingey D. T., R. C. Fites and C. Wickliff. 1975. Activity changes in selected enzymes from leaves following ozone exposure. *Physiol. Plant.* 33, 316-320.

Tran Thanh Van M. et Nguyen Thi Dien.1975. Etude au niveau cellulaire de la diffe-reneiation *in vitro* et de *nova* de bourgeons veg4tatifs, de racines ou de cal A partir de couches minces de cellules de type epidermique de *Nicotiana tabacum Wsc.38. Can. J. Bot.* 53, 553.559.

Tran Thanh Van M. et Chlyah A.1976. Analyse au niveau infrastructural des premiers stades de diffdrenciation de boutons floraux, de bourgeons vegetatifs, de racines et de cal a partir des couches cellulaires minces de type 6pidermiqu *des* ramifications florales de *Nicotiana tabacum Wisc.3d. Can. J. Bot.*

Wann M., C. D. Raper and H. L. Lucas. Computer simulation of dry matter production for tobacco. *26th Tobacco Workers Conference, Charleston* S. C. Jan.1975.

Wellensiek S. J. The influence of Photoperiod and of GA on flower development and stem elongation of *Silene armeria* 1976. *Proc. Kon. Ned. Akad. Netensch. Amsterdam,* C 79, 1, 84-89.

Wellensiek S. J. S-tem elongation of "dwarf" *Silene* armeria *L.* as influenced by generative condition and GA .1976. *Proc. Kon. Ned. Akad. Wetensch. Amsterdam* C 79, 1, 90-94.

Wu, Lin and J. Antonovics. Experimental ecological genetics in *Plantago.* I. Induction of roots and shoots on leaves for large scale vegetative propagation and metal tolerance testing in *P. Lanceolata. New Phytol.* 75, 277-282, 1975.

Wu , Lin and J. Antonovics. Zinc and copper uptake by *Agrostis stolonifera.* Tolerant to both zinc and copper. *New Phytol.* 75, 231-237.1975.

XXX- EVENTS, MEETINGS AND EXHIBITIONS PLANNED

1976. Decembre Toulouse (France)
Stage de Formation continue : *Traitement de* la *pollution industrielle*
Renseignements : CFC Polytechnique- Place des Hauts Murats, BP 354, 31006-Toulouse Cedex (France)

1976.6-9 Decembre Grignon (France)
La manutention en agriculture , cycle de Formation continue
Renseignements : Centre de Perfectionnement INA Paris-Grignon, 16 rue Claude Bernard, 75231. Paris Cedex 05

1976.7-11 Decembre. Paris-France
2ame Semaine Internationale de l'Environnement
tare Exposition Professionnelle pour l'Amenagement et l'Entretien des Espaces verts
Renseignements ; G.. E. R. P., 12 rue Chabanais, 75002. Paris (France)

1976.13-15 Decembre Toulouse (France)
Stage de Formation continue : *Controle de la fertilisation par l'analyse du vegetal.*
Renseignements: CFC Polytechnique. Place des Hauts Murats, BP 354, 31006-Toulouse Cedex (France)

1977. Quebec (Canada)
International Floralies of Quebec
Inquiries: Organizing Committee, 2527 Gregg. Str. Sainte Foy, Quebec, Canada 61 WI J5

1977. Ireland
Symposium on Mushrooms
Inquiries: Dr. D. W. ROBINSON, Kinsealy Research Center an Foras Taluntais, Malahide Road, Dublin 5-Ireland.

1977. *VIth ISHS Symposium on Horticultural Economics*
Inquiries: WG.. De HAAN, Conradkade 175 the Hague (Netherlands)

1977. Twin symposia (North America and Europe/USSR) on *Winter injury and Rootstock Breeding*
Inquiries: Dr. F. R. TUBBS c/o John Innes Inst. ColneyLane Norwich NOR 70 F UK

1977.9-12 janvier. Bruxelles *Belgique*
ler salon technique pour les fleuristes (FLOREX)
Renseignements :FIBPalais du Centenaire B-1020 Bruxelles. Belgique.

1977.17-20 janvier. Grignon (France)
Insecticides et fongicides de *troisieme generation a activite biologique,*
cycle de Formation continue.
Renseignements : ADEPRINA.161 rue Claude Bernard, 75231. Paris Cedex 05.

1977. January-February Berlin (FRG)
Internationale Grune Woche.

1977.79 fevrier Paris (France)
Secheresse at besoins en eau des cultures , cycle de Formation continue
Renseignements: ADEPRINA.16 rue Claude Bernard, 75231. Paris Cedex 05.

1977.11-18 February. Canberra. Australia
IIIrd Int. Congress of the Society for the Advancement of Breeding Researches in Asia and Oceania (SABRAO)
Inquiries: A. C. DOERY , CSIRO PO Box 225 Dickson ACT 2602 Australia.

1977. February 14-18. Cape Town South Africa
International Symposium on the Quality of Vintage
Inquiries: Oenology and Viticulture Research Institute
Private Bag X 5026. Stellenbosch 7600 South Africa.

1977. February 28-March 2. Beltsville (USA)
Annual *Meeting of ASHS Growth Chamber Committee*
Inquiries: T. W. TIBBITTS, University of Wisconsin, Dept. Of
Horticulture 1575 Linden Drive Madison Wis; 53706. USA

1977.2-6 avril 1977. Limoges France
102e Congres National des *Societes Savantes*
Dans la section des Sciences: 4-Biologie vggetale et 5-Biologie animale.
Renseignements: Congres national des Socigtes Savantes. Bibliotheque
nationale. 58 rue de Richelieu, 75084-Paris Cedex 02 France.

1977. April 7-8. Tucson (Arizona USA)
Symposium on Protected cultivation.
Inquiries : Dr. JENSEN-University of Arizona-Environmental Research Laboratory.
Tucson Arizona 85706 USA.

1977. April 11-16. San Diego (USA)
The International Agricultural Plastics Congress NAPA.
Theme for the International gathering will be: "Food for World Survival"
Inquiries: C. D. GUSTAFSON, Chairman Program Committee 1616 Silvas str. Chula Vista Calif.92011 USA
As complement to the Congress: *Agricultural Plastics Exhibit*
Inquiries: Jim ROBERTS, Exhibits Manager International Agricultural Plastics Congress, 700 Rancheros Drive, San Marcos Calif.92069. USA

1977.29 avril au 23 octobre. Bundesgartenschau. Stuttgart (FRG)

1977. Sheraton Hotel Orlanda (Florida USA) **flo./.1-7,**

IInd International Citrus Congress (ISC)
Inquiries: H. REITZ, President ISC. Agricultural Research and Education
Centre PO Box 1088 Lake Alfred 33850 Fla USA.

1977.3-6 Mai . Grignon (France)
PhotosyntUse et production vegetale, cycle de Formation continue
Renseignements: ADEPRINA.16 rue Claude Bernard, 75231. Paris Cedex 05.

1977. May 3. Gent Belgium.
29e Internal Symposium on Crop Protection
Inquiries: Secretariat. Faculteet van de Landbouwwetenschappen Coupure Links 533 B 9000 Gent. Belgique.

1977. May 3-5. Bratislava (Czechoslovakia)
Symposium on the use of artificial light in experimental botany, horticulture and agriculture.
Inquiries : Dr. J. KREKULE. Institut of Experimental Botany
Dept. Of Growth and Development. Ke dvoru 16/15 Vokovice
PRAHA 6 -Czechoslovakia.

1977. May 9 -I4. Antibes France
Symposium on Carnations (ISHS)
Inquiries: Secretariat Symposium Oeillet (ISHS)
CNRS. BP 78.06602. Antibes France

1977. May 9-14 Madrid (Spain)
18th International Seed Testing Congress (ISTA)
Inquiries: ISTA Secretariat Box 68, N-1432-AAs-NLH-Norway

1977.12-23 mai. Nantes France
Flora lies internationales
Renseignements: Comite d'organisation.3 place de la Petite Hollande BP 237
44000 Nantes, France

1977. May 16-18. Nantes. France
International Congress on Camelia
Inquiries: Organising Committee.3 place de la Petite Hollande, BP 237 4, 000-Nantes. France

1977. June 21-25. Moscow USSR
World Electrotechnical. Congress WELC
Inquiries: Organizing Committee of WELC
Kalinina prospect 19 Moscow G 19 USSR

1977. July 4-9th. Halle-Saale (GDR)
International Conference on Regulation of Developmental Processes in Plants.
Sections : 1-Protein Pattern and regulation of Differentiation
2-Regulation of Organelle Biogenesis
3-Regulation of Differentiation in Cell and Tissue cultures 4-Regulation of Development by interactions of Plant Hormones or other Substances
Inquiries : Secretariat of Conference. c% Institute of Plant Biochemistry of Ac. Sc. Of GDR. P 0 Box 250 DDR 401 Halle-Saale-German Democratic Republic

1977. July 5-8. Montfavet-Avignon France
III rd Eucarpia Meeting on Pepper
Inquiries: Mr. E. POCHARD, Capsicum Eucarpia Meeting . INRA Domaine Saint Maurice 84140-Montfavet. Avignon. France

1977. July 11-13 Munchen (RFA)
IIIrd International Meeting on Grass and lawns
Inquiries: Deutsche Rasengesellschaft c/o Institut fur Planzenbau 5300 Bonn I Katzenburgweg 5 (RFA)

1977. July 18-23 Wellesbourne (UK)
ISHS Symposium on Timing of Field production of Vegetables
Inquiries: Dr. GRAY. Nat. Vegetable Research Station. Wellesbourne Warwick CV35 9EF. U. K.

1977. August 22-26 Alnarp (Suede)
ISHS International Symposium on more profitable use of energy in protected cultivation.
Inquiries: Secretary-Dept. Of Floriculture and ornamental Horticulture-Agricultural University of Sweden 5.230-53 Alnarp Suede

1977. August 23 -25. Wilhelminadorp (The Netherlands)
MRS Symposium on Intraclonal selection in apple and pear
Inquiries. Dr. H. J. Van ()OSTEN. Research Station for Fruit Growing. Wilhelminadorp. The Netherlands.

1977. August 23-27. Cacak Yugoslavia
Ilird Meeting of the Working Group on Plum Genetics and Plum Breeding
Inquiries: Dr. Stanisa A. PAUNOVIC. Fruit Research Station Cacak. Yugoslavia.

1977. August 29r-September 2. Japan
8th Int. Congress. Int. Union of Biological Science
Inquiries: Dr. Hiroshi TERAYAMA. Zoological Inst. Fac. Of Science Univ. Of Tokyo. Hongo. Bunkyo Ku Tokyo 113. Japan.

1977. September. Yugoslavia
ISHS symposium on Growth regulators in fruit production.
Inquiries: Dr. LUCKWILL. Long Ashton Research Station Bristol BS 18 9 AF. U. K.

1977. September 1 -14. Bet Dagan Israel
ISHS Symposium Water Supply and irrigation
Inquiries: Mr. SCHALLINGER. The Volcanic Center POB 6 Bet Dagan Israel

1977. September 4-7 PAVIA (Italie)
XIII International Conference of Society for Chronobiology
Topics: Methodology of data collection-Transfer and analysis -Biometrical reference intervals-Endocrinology-Cell biology -Shiftwork -Chronopharmacology -Cancer -Nutrition-Education Agriculture
Inquiries: Secretary Office.' S C XIII Conference -P 0 Box 1071 20100 Milano (Italia)

1977. September 4-10 Tokyo (Japan)
26th International Congress of pure and applied chemistry
Inquiries: 26th Congress of IUPAC -Po Box 56, Kanda Post Office, Tokyo 101-91 Japan.

1977. September 4-10 Reading UK
IV Int. Congress on Photosynthesis
Inquiries: Prof. D. O. HALL. King's College, 68 Half Moon Lane London SE 24-9JF U. K.

1977. September 7 -9. Ghent Belgium
ISHS Symposium on in vitro culture for horticultural purposes
Inquiries: Prof. G. BOESMAN. Coupure Links 533.9000 Ghent. Belgium

1977. September 12 -16. Dublin (Ireland)
ISHS Symposium on the Propagation and raising of nursery
Topics: 1) Physical and physiological factors in rooting.2)Chemical aids to vegetative propagation.3)Use of plastics in propagation.4)Container -grown -stock compost and nutrition.5)Mechanisation.6)Preservation in cold storage.
Inquiries: J. C. KELLY. Kinsealy Research Centre. Malahide Road. Dublin 5, Ireland

1977.12-30 Septembre Paris (France)
Microbiologie du sol et des eaux, cycle de Formation continue.
Renseignements: ADEPRINA.16 rue Claude Bernard, 75231. Paris Cedex 05.

1977. September 19-22 Dublin (Ireland)
ISHS Symposium on production of protected crops in peat and other media
Topics: 1) Physical and chemical properties of peat and other substrates.2)Materials for potting composts.3) Analysis of substrates.4)Macro and micro-element nutrition, slow release fertilisers.5)Disease control, sterilisation and re-cycling of substrates.6)Complete cultivation of crops in peat and other media including nutrient solution.7)Irrigation of the growing medium including use of capillary matting.
Inquiries: M. J. MAHER. Kinsealy Research Centre, Malahide Road Dublin 5, Ireland.

1977. End September Nottingham (UK)
ISHS Symposium on seed problems in horticulture
General topics: 1) Seed production.2)Special germination problems.3)Health and vigour.4)Improvement of *seed* performance.5)Special features (storage-testing techniques thermogradient and other devices)
Inquiries:Dr. W. HEYDECKER. University of Nottingham School of Agriculture and Horticulture. Sutton Bonington. Loughborough LE 12-5RD England UK

1977. October 5-7. Beltsville USA
International Symposium on Calcium Nutrition of Economic Crops
Inquiries: C. B. SHEAR. Beltsville Agricultural Research Center Beltsville Ma.20705 USA

1977. November 27-December 2nd. Khartoum-Sudan
5th African Symposium of Horticultural Crops (ISHS)
Theme: Horticultural research and development in the arid zones of Africa.
Inquiries:Dr. A. T. ABDEL HAFFEZ. Dept. Of Horticulture University of Khartoum Shambat. The Sudan

1978. May 31-June 9. Paris France
Xth International Congress on Mushroom Culture
Inquiries:Secretariat 10e Congres Champignons Comestibles , INRA Bordeaux, 33140. Pont de la Maye. France

1978. July 24-28. Zurich Switzerland
IVth Inst. Congress of Pesticide Chemistry
Inquiries-Secretariat PO Box 182. CH.4013. Basle Switzerland

1978. August 15-23. Sydney (Australia)
20th International Horticultural Congress
Inquiries: Secretary of Congress. GPO Box 475 Sydney N S W 2001 (Australia)

1978. August 16-23. Munich Germ. Fed. Rep.
3rd International Congress on Plant Pathology
Inquiries: Congress Plant Pathology. Biologische Bundesaustalt Messeweg 11/12 D.3300. Braumschweig F. R. Germany

1978. August 21-30 Moscou (USSR)
loth International Congress of Genetics
Inquiries: Organizing Committee XIV-ICG. Rue Fersman 11, apt 4. Moscow 117312. USSR

1978.18-29 octobre. Iberflora . Valencia Espagne
Inquiries: IBERFLORA. Apartado 13, Valencia (Espagne)

1979. Danemark
Symposium "Production planning in protected cultivation"
Inquiries: M. G. AMSEN. State Glasshouse Crop Research Station Virumvej 35.2830. Virum. Danemark

1979.28 avril-17 octobre. Prague (Tchecoslovaquie) Exposition horticole 1979.6 mois undesgartenschau BONN (FRG)

1980. Avril Gand (Belgique).
Floralies gantoises

1980. 6 months. *Exposition nationale horticole. Bale (Suisse)*

1981. Avril Genes (Italie)
Eurofiora.

1982. 6 months *Floriades des Pays-Bas.*

1982. Hambourg (FRG)
21st International Horticultural Congress.
Inquiries: Prof. D. FRITZ. Institut fur Gemusebau 8050 Weihenstephan-Freising/00B. Germany, Fed. Rep.

1983. 6 months I G A a Hambourg (FRG)

1984. 6 months W I G , Vienne (Autriche).

1985. Avril. *Floralies gantoises* (Belgique).

- o

We thank, in advance, all those who will be sending us reports or news to print in coming issues .

R. Jacques and N. De Bilderling.