Secretariat Phytotroaique
Phytotron. C. N. R. S.
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PHYTOTRONIC NEWSLETTER No 20

(IMPORTANT INFORMATION

At the next International Botanical Congress in Sydney, Australia, in August 1981 a session will be organized entitled: "The Contributions of Phytotrons to Plant Improvement and Botanical Research".

The following subjects in particular will be discussed at this session by means of invited and submitted papers, posters and exhibits illustrating various subjects and specially: controlled environment equipment and apparatus, measurement techniques, and their standardization, arrangements for the efficient management of phytotrons, etc.

Those interested in more information, whether they are manufacturers or users: contributors or commercial firms should write to:

Dr. L. T. Evans, CSIRO, Division of Plant Industry, P. O. Box 1600, Canberra City ACT 2601, Australia.

Contents of Phytotronic Newsletter n° 20

I. EDITORIAL

The last two issues were published thanks to a special grant from the Directors of the CNRS (The French National Center for Scientific Research) which has been carried over for this 20th issue as well.

Sincere thanks to all those who are helping us to resolve the financial problems encountered.

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We also would like to thank those of you who have sent us benevolent financial aid. As usual, we would like you to address your donations to our intermediary, stating "Participation aux frais de parution de Phytotronic Newsletter", and making cheques payable to:

L'Agent Comptable secondaire du CNRS- 4ame circonscription 91190-Gif/Yvette.

Postal cheques or money orders should be made out to:

L'Agent Comptable secondaire du CNRS-4ame circumscription CCP Paris 913848 U Paris.

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The current issue is composed of the following four sections:

Annual Reports and Meetings which includes extracts from two 1977 Annual Reports and short summaries of two important scientific meetings, one of which was held at Gif-sur-Yvette (France) in 1978 on Flowering and the other in Madison, Wisconsin (USA) in 1979 on Environmental Control.

In the section News from Laboratories readers can find, at first, passages from publications of the Institute for Horticultural Plant Breeding (I V T) in Wageningen (The Netherlands) whose Phytotron celebrated its 25th year of existence in 1978, and secondly, passages from a Manual for Investigators of Madison Biotron, Wisconsin (USA).

The section Research Strategy contains several articles or scientific papers from authors in different countries on horticultural techniques, modelization, root measurement and the effectiveness of photosynthesis or morphogenesis.

Finally, the Miscellaneous News that we gather will hopefully be useful to our readers. We would appreciate being informed of meetings and other activities of interest to publish in our NEWSLETTER.

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In conclusion we ask our readers to send us documents, news, technical memos or scientific articles on applied or fundamental research in plant physiology and horticulture likely to interest all "phytotronics".

We thank you in advance,

R. Jacques and N. De Bilderling

II. REPORT 1977. PHYTOTRON. NCSU. (USA)

Editor's Note. We receive from Dr. D. J. Downs the 1977 annual report of the North Carolina State University Phytotron (120 pages) from which we reprint certain passages. Those readers who desire more information please write to: NCSU. SEPEL.2003 Gardner Hall Raleigh N. C.27607. USA.

DITRODUCTION

The NCSU Phytotron operated at about optimum capacity during 1977. Towards the end of the year over 90% of the chamber space was in use with about 1/3 of it devoted to off-campus investigators. Current schedules predict a similar high use rate during the first half of 1978. The increased use of the Phytotron by off-campus investigators is encouraging in that it allows us to fulfill the objective of a truly regional facility.

The NCSU Phytotron is continuously being modified and improved to provide better and ever more reliable control of environmental factors, as well as to meet the different requirements imposed by new research programs. During 1977, we consolidated and completed modifications begun earlier and began research and development of several new ones. The microprocessor based controller, for example, was rebuilt after preliminary testing. The chambers were rewired and half of the A and half of the 3 chambers are now operated by the microprocessor unit.

The air pollution research laboratory has redesigned the gas tight treatment roomettes. Inlet air ducts were relocated to provide for better CO., control, and mixer baffles were installed. Since ethylene is used to calibrate some of the instruments, a thermal catalyst was attached to insure all traces of ethylene are destroyed. Proportional controllers and fine metering valves were installed to provide better temperature and relative humidity control within the roomettes.

The automatic watering system works reasonably well, but we are continuing to evaluate emitters and manifold designs. Alternating water and nutrient applications has posed the problem of removing the residual amounts of one from the piping before applying the other. Several methods of doing this are under consideration.

Several C chambers were changed from direct expansion compressors to secondary coolant from remote compressors. As expected, chamber vibration was virtually eliminated. Performance, however, was not as good as indicated in the prototype test, so additional changes in the design were necessary. Heavy demand for C chamber space has slowed the conversion process because we make the changeover without interfering with the research programs.

The dual continously stirred tank reactor (CSTR), designed for gazeous uptake studies, has been in use throughout the year. No difficulties or maintenance problems were encountered.

The continuous flow liquid culture system designed by C. D. Raper, Jr., and co-workers for maintaining root temperature also operated successfully throughout the year. The only modification necessary was a change in the material of the cooling coils to avoid any risk of contaminating the nutrient solution.

RESEARCH REPORTS

Research using the NCSU Phytotron during 1977 covered a wide range of endeavor. The involvement of nutrition and various environmental factors in the physiology of flowering and fruit production received considerable emphasis. Air pollution research programs and investigations in tissue and cell culture were active throughout the year. Plant responses to environment for *use* in mathematical models are being studied in detail.

List of the investigations during 1977 relate the research programs.

a) Air pollution research H. H.

Rogers, J. A. Dunning and W. Heck.

I. Snap bean: a model to study the effects of gaseous pollutants on crop productivity
2. Determination of gaz exchange using the CSTR system and studying 0_3-NO_2 and NH_3.

R. A. Reinert. Effects of growth and exposure temperature on ozone sensitivity and growth of tomato, pepper and radish.

U. Blum. Effects of ozone on snapbeans (Bush Blue Lake 290)

U. Blum. Effects of ozone on carbohydrate allocation in bush bean.

W. W. Heck and J. Dunning. Effect of environment on 03 uptake by bean plants.

R. A. Reinert. Effect of growth and exposure temperatures on sensitivity of five plant species to ozone.

b) Entomology

P. S. Benepal and M. Rangappa. Implications of using unsexed mexican beans beetles in screening beans for resistance.

G. H. McKibben and Virginia Naylor. Controlled release formulation of synthetic phezomimes and cotton plant volatiles.

c) Environmental physiology

J. F. Thomas. Environmental physiology of Glycine max (L.) Merrill.
a) Effect of End of Day Illumination on Soybean Development
b) Effect of Cool Temperatures on Multiple Carpel Formation
c) Effect of Day and Night Temperatures During Floral Induction

D. L. Thompson. Temperature, light and gaspe flint corn

M. R. Eure and D. A. Emery. Effects of photoperiodism on peanut (Arachis Rypogea L.) peg elongation.

P. S. Benepal and M. Rangappa. Screening beans (Phaseolus vulgaris L.) for tolerance to temperature extremes.

I. A. Mendelssohn and E. D. Seneca. The affect of soil aeration and thermoperiod on the growth response of Spartina Alterniflora.

D. A. Emery. The genetic control of reproductive efficiency in peanuts: response to photoperiod.

M. D. Cross, D. W. Israel and W. A. Jackson. Soybean reproductive physiology.

J. P. Thomas. Effect of cool temperatures on multiple carpel formation in soybean.

J. P. Thomas and C. D. Raper, Jr. Effect of Length of photoperiod on floral initiation and anthesis in soybeans.

d) Genetics and Plant Breeding

W. D. Hanson. Genotypic differences affecting transport of assimilates from soybean leaves (Glycine max L.) Merrill.

C. F. Murphy. Intensification of wheat breeding programs

W. D. Hanson. Genotypic differences among soybean genotypes affecting mg DM $^{-2}$ h^{-1} under conditions leading to differential accumulation of assimilate in the leaf.

D. A. Emery. The genetic control of reproductive efficiency in peanuts: response to photoperiod.

e) Horticulture

F. A. Blazich. Effects of ambient temperature on rooting stem cuttings of Ilex crenata Thumb. Cv. Convexa and Rhododendron obtusum cv. Hershey red.

P. S. Benepal and D. P. Mbhan. Variability in chemical composition of bean (Phaseolus vulgaris L.) cultivars.

V. P. Bonaminio. Growth and flowering of Thumberlia fragans Roxb. Var. "white wings" in controlled environments.

V. P. Bonaminio and R. A. Larson. Influence of split night temperatures on bud set, flower development and growth of Chrysanthemum morifolium Ramat cv "may shoesmith".

V. P. Bonaminio. Utilization of selected chemical compounds to alter the pH of pine bark humus.

C. H. Miller, D. H. Willets and W. C. Fonteno. Effects of light intensity on the growth and yield of two varieties of greenhouse tomatoes.

Ch. Auman and R. A. Larson. Environmental factors influencing the uniformity of bud set in Rhododendrons.

R. A. Larson and V. P. Bonaminio. Growth and flowering of Domeya and Thunbergia as influenced by temperature and photoperiod.

R. K. Kimmins and R. A. Larson. Response of Pilea species to various growth regulators.'

V. P. Bonaminio and R. J. Downs. Influence of four commercially available fluorescent light sources on growth and development of bedding plants.

P. V. Nelson. Cultural requirements for Stapelia.

K. W. Jones, D. C. Sanders and G. R. Hughes. Salt stimulation of pepper seedling emergence.

V. P. Bonaminio and R. A. Larson. Influence of split night temperatures on bud set, flower development and growth of Chrysanthemum.

V. P. Bonaminio and R. A. Larson. Influence of night temperature on flowering of Cyclamen persicum.

V. P. Bonaminio. Ancymidol effects on Poinsettia grown in pine bark humus amended with calcined clay.

R. C. Long and S. Jalli. Effect of Alar on plant growth at Low temperature

f)Mathematical models

F. R. Cox. Effect of temperature and radiance on the growth and development of peanuts (Arachis hypogaea L.)

C. D. Raper,Jr, and M. Wann. A dynamic model for simulation of soybean growth. g) Nitrification

P. E. Bishop. Isolation and characterization of mutant strains of rhizobium unable to form nodules on Phaseolus Lathyroides.

h)Nutrition

J. J. Nicholaides and F. A. Mombiela. Sorghum response to various initial and applied P levels under several environmental conditions.

F. R. Cox. Diagnosis and correction of manganese and molybdenum problems in legumes.

G. S. Miner and T. Rufty. Effect of temperature on manganese uptake and toxicity in flue red tobacco.

E. E. Pattee and Carrie Crompton. Interaction of calcium nutrition and temperature during the development and differentiation of the peanut pod.

i)Pathology

W. Kongpolprom and W. R. Henderson. The study of the interactions of tomato lines, isolates, and isolate concentrations of Alternasia solani (Ell and .!art) fungus under two temperature conditions.

R. E. Welty. Effects of freezing in predisposing alfalfa to damage by Scierotina trifoliorum.

C. A. Clark and J. N. Sasser. The effect of initial population density of selected plant pathogenic nematodes on growth of cotton.

R. E. Welty. Studies in the epidemiology of Anthracnose of alfalfa.

W. B. Nesbitt and P. J. Bloodworth. Inheritance of resistance/immunit9 to root knot nematode in Euvitis-Muscadinia hybrids: effect of temperature on plant-parasite relationships.

R. E. Welty. Effect of injury on crown and stem rot in alfalfa.

M. S. Zuber and D. L. Thompson. Corn aflatoxin.

j)Seed germination

J. Stucky. Germination and development of weed species common to North Carolina.

S. C. Weller. Germination of Heterotheca subaxillaria.

H. Beaufort-Murphy. Investigation of seed size and germination capabilities in relation to position in the fruit of selected Streptocarpus species.

T. D. Bost. Factors related to Kalmia latifolia germination

H. Brooks and G. R. Noggle. Influence of cytokinins and abscisic acid on cotyledon expansion and modifications by inorganic salts.

Diane McLean and G. Sullivan. Germination of peanut seeds.

k) Tissue and Cell Culture

R. L. Mott. Phytotron studies of tissue culture propagation of pine. S. M.

Flashman. Characterization of tobacco cell lines resistant to selenoamino acids.

C. Kelly, G. Leach, B. Zobel and R. Mott. Clonal variation and genotype x environment interaction studies using clonal material from tissue cultures.

M. Horner and R. Mott. Influence of cold shock on haploid plant production from pollen grains

R. L. Mott. Diurnal temperature and light effects on morphogenesis in conifer tissue cultures.

1) Tree physiology

E. Butler-Schultz and R. C. Kellison. Cold hardiness testing of Eucalyptus.

Ch. Black and C. D. Davey. Factors influencing the growth of containerized Frasier fir seedlings.

m) Water relations

C. J. Phene and all. The affect of controlled soil metric potential on dry matter accumulation of cotton under controlled environment

R. P. Patterson. Influence of water stres on growth, nitrogen and carbon assimilation, and energy status of soybeans growing under variable temperature conditions.

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III. CSIRO. DIVISION OF IRRIGATION RESEARCH
Annual report **1977**

Editor's Note. We receive from Commonwealth Scientific and Industrial Research Organization (CSIRO, Division of Irrigation Research, Griffith NSW 2680 Australia) their annual report 1977 from which we reprint their research objectives. Those readers who desire more informations please write directly to this division in Australia.

1. CROP GROWTH AND MANAGEMENT

Photosynthetic rates and productivity of pineapples and potatoes
Rice stubble disorder in wheat and maize
Influence of irrigation frequency on snap bean yield and quality
Physiology of green beans in relation to yield and adaptation to irrigation
The effect of sowing data on sweet corn development
Comparison of yield and maturity in sweet corn cultivars
A method for determining the quality of sweet corn to be used for freezing
Effect of soil management on soil temperatures in an orange orchard

Oilseeds breeding of safflower and sunflower
Root rot disease of safflower
Bacterial inoculation of safflower seed: towards biological control of root rot disease
Enumeration of Phytophtora zoospores in irrigation waters

2. WATER MANAGEMENT AND ENGINEERING IN IRRIGATION

Management, colonization, vigour, growth and reproduction of Canadian pondweed
Control of submerged aquatic plants with triazines
Fields and glasshouse trials of terbutryn in flowing and pounded water
Soil residual herbicides in irrigation water
Residues of glyphosate in irrigation water
Distribution and biology of salvinia
Autecological studies of other alien aquatic weeds
Water quality studies
Effect of European carp on aquatic ecosystems
Nutrient film hydroponics
Irrigation systems for remote locations

3. ENVIRONMENTAL PLANT PHYSIOLOGY AND BIOCHEMISTRY

The distribution of fructans in onions
Carbon translocation in onion
Nutritional and root temperature factors affecting growth and yield of onions
Photosynthetic rates and productivity of onions
Carbon and nitrogen metabolism in plants
Soil aeration status and denitrification
Enumeration of micro organisms involved in particular mineral transformations
Changes in populations of selected micro organisms in recently drained rice soils
Effects of soil flooding on the survival and root colonization of vesicular arbuscular mycorrhizal (TAM) fungi
Assessment of citrus plant water potential
Hydraulic resistances in the citrus plant
Aspects of photosynthesis in citrus

4. MEASUREMENT STUDIES AND SUPPORT SERVICES

Greenhouse thermal studies
Solar energy usage in greenhouses
Data capture systems Computer new devices
Service, maintenance and field data logging
Oil quality and quantity testing using gas chromatograph, wide band and pulsed nuclear magnetic resonance oil meters
Analysis of plant sap
Analytical methods for herbicides in irrigation water.

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IV. INTERNATIONAL COLLOQUIUM ON THE PHYSIOLOGY OF FLOWERING

July 17-21, 1978 -Gif-sur-Yvette (France).

The CNRS International Colloquium on the Physiology of Flowering was held at the initiative of numerous French and foreign researchs, wanting to compare results and ideas on the ancient, but complex subject, of plant physiology.

At this Colloquium, the national and international scientific community paid homage to Professor P. Chouard, founder of the GNRS French Phytotron at Gif/Yvette, where he introduced a large variety of plants for experiments on the determinism of flowering. It was nearly 30 years ago, at a lecture he gave at the Palais de la Decouverte in Paris, that Professor Chouard recalled the different paths of research linked to flowering: structural modifications during the shoot-bud passage, the role of nutritive materials, the role of hormonal substances, the effects of the CO_2 and 0_2 content of the atmosphere, the effect of temperature and light, the intervention of light "in a very varied, very subtle way during the passing of time or during the localization of application points".. These questions remain of current interest, and it was so decided, to organize working group discussions around themes, of which one represented the geneticists' point of view. After comparison of the results achieved and discussions/ the participants attempted to open up new areas of research. During the Colloquium, each working group drafted a preliminary report which **was** then taken **yp** in plenary discussion session. The six reports, then, resulted from a group effort.

The six working groups were:

Group 1: Stimulation, inhibition of flowering: morphological and physiological studies. Chairman/ J. Krekule (Czechoslovakia)

Group 2: Perception, nature and complexity of transmitted signals. Chairman, J. A. D. Zelavaart (USA)

Group 3: Effect of photoperiod and phytochrome in flowering: time measurement. Chairman,D. Vince-Prue (UK)

Group 4: The sequences of flower-evocation. Chairman, G.3ernier (Belgique)

Group 3: Metabolism and energetics in flowering. Chairman, R. Sachs (USA)

Group 6: Genetic systems involved in the flowering process . Chairman, J. Pernes (France

In the 17th issue of the PHYTOTRONIC NEWSLETTER (February 1978, page 81) we announced the organization of this Colloquium. The Minutes of these meetings are currently in the process of being published. A future announcement will be made when the volume is published.

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V. CONTROLLED ENVIRONMENTS WORKING CONFERENCE

Dr. D. T. Krizek, Plant Stress Laboratory U. S. Department of Agriculture, SEA, AR, Beltsville, Maryland 20705

Over 100 participants attended a two and one half day Controlled Environments Working Conference at the University of Wisconsin, in Madison, Wisconsin, on March 12-14, 1979. The conference was organized by the U. S. Department of Agriculture, Science and Education Administration (USDA, SEA) North Central Region 101 Committee on Growth Chamber Use. Co-sponsors of the conference were the American Society for Horticultural Science (ASHS) Working Group on Controlled Environments and Growth Chambers, the American Society of Agricultural Engineers (ASAE) , SE-303 Committee on Environment of Plant Structures, and the Biotron, University of Wisconsin.

Dr. T. W. Tibbitts, Department of Horticulture, University of Wisconsin, served as overall coordinator of the conference and represented the NCR-101 Committee. Assisting him as representatives of their respective organizations were J. C. McFarlane (ASHS), R. P. Prince (ASAE), and T. T. Kozlowski (Biotron).

The conference was divided into two sessions. Session I was chaired bw T. T. Kozlowski, Director, Biotron, and dealt with requirements for controlling and measuring various critical environmental factors in controlled environment studies.

Keynote addresses were presented on: radiation by Keith J. McCree (Texas A. & M University, College Station) ; temperature by Frank B. Salisbury (Utah State University, Logan); humidity by Glenn J. Hoffman (U. S. Salinity Laboratory, USDA, SEA, AR, Riverside, California); carbon dioxide by James E. Pallas (USDA, SEA, AR, Watkinsville, Georgia); watering by Steven L. Rawlins (U. S. Salinity Laboratory, USDA, SEA AR); and interactions by Wade L. Berry (University of California, Los Angeles) and A. Ulrich (University of California, Berkeley). The keynote address on precision and replication was prepared by C. H. M. van Bevel (Texas A & M University) and was given by Brent McCown (University of Wisconsin, Madison).

Discussants on radiation included R. J. Downs (North Carolina State University Biotron, Raleigh) and E. D. Bickford (Duro-Test Corporation, North Bergen, New Jersey). Discussants on temperature were Champ B. Tanner (University of Wisconsin, Madison) and Roger P. Searls (Sherer Environmental Division of Kysor Corporation, Marshall, Michigan). Discussants on humidity were George F. Thurtell (University of Guelph, Guelph, Ontario, Canada) and John Forrester (Scientific Systems, Inc., Baton Rouge, Louisiana). Discussants on carbon dioxide were Henry Hellmers (Duke University, Phytotron, Durham, N. C.) and Herschel H. Klueter (USDA, SEA, AR, Beltsville, Maryland). Discussants on watering were Gaylon S. Campbell (Washington State University, Pullman) and Merrill R. Kaufmann (U. S. Forest Service, Fort Collins, Colorado). Discussants on precision and replication were Henry Kotstkowski (National Bureau of Standards, Washington D. C.) and P. Allen Hammer (Purdue University, West Lafayette, Indiana).

Session II was chaired by Ralph Prince (University of Connecticut, Storrs) and covered NCR-101 guidelines for making various environmental measurements and for reporting these data in scientific journals.

Measuring and reporting guidelines with recommended units were introduced by R. Bruce Curry (Ohio Agricultural Research and Development Center, Wooster). Recommendations of the committee were then presented on: radiation by J. C. McFarlane (Environmental Protection Agency, Las Vegas, Nevada); temperature by Lawrence R. Parsons (University of Minnesota, St Paul); humidity by L. Art Spomer (University of Illinois, Urbana); carbon dioxide by Donald T. Krizek (USDA, SEA, AR, Beltsville, Maryland); and air movement by Murray Duyson (North Dakota State University Fargo).

Dr. Paul J. Kramer, emeritus professor of botany (Duke University, Durham, North Carolina) gave a final address to summarize and comment on the conference.

The dedicated efforts of T. W. Tibbitts, Department of Horticulture, University of Wisconsin, were in large part responsible for the success of the conference. Assisting him in providing outstanding local arrangements were staff members of the Biotron (Larry Anderson) and the Departments of Agricultural Engineering (Cal Cramer), Horticulture (Brent McCown), Agronomy (Larry Schrader) and Soils (Champ Tanner).

The conference was highlighted by a free and active exchange of ideas by all participants, a tour of the Biotron, and a poster session, demonstrating equipment and facilities for controlled environment use. Strong recommandations were made by members of the NCR-101 Committee in support of using SI units.

Financial support for the conference was provided by: the National Science Foundation; USDA, SEA; the University of Wisconsin Graduate School; the University of Wisconsin College of Agricultural and Life Sciences; and General Mills, Inc.

The proceedings of the conference will be edited by T. W. Tibbitts and T. T. Kozlowski and will be published by Academic Press under the title: Controlled Environment Guidelines for Plant Research.

The NCR-101 Committee convened on Sunday afternoon, March 11, preceding the conference and the ASHS Working Group on Controlled Environments and Growth Chambers convened on Wednesday afternoon, March 14 and all day Thursday, March 15.

Editor's Note. Readers who desire buythe proceedings of the conference when they will be published, please write directly to: Dr. T. W. Tibbitts, Dept of Horticulture. University of Wisconsin 1575 Linden Drive- Madison Wisc. 53706-USA.

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VI. IVT FHYTOTRON 1953-1978

PLANT BREEDING RESEARCH UNDER CONTROLLED CONDITIONS IN HORTICULTURAL CROPS

Editoes Note. We receive from Dr. L. Smeets, physiologist in charge of this Phytotron, the silver jubilee book published in special edition by Netherlands Journal of Agricultural Science (n'26 , 1978, 132 pages). For our readers we reprint below: table of contents, the foreword and the description of the Phycotron. Those readers who desire more informations please write directly to the following address: Institute for Horticultural Plant Breeding (IVT). Mansholtlaan IS, Postbus 16, Wageningen, The Netherlands.

CONTENTS VOLUME 26 (1978) OF NETHERLANDS JOURNAL OF AGRICULTURAL SCIENCE

FOREWORD

by C. Dorsman, Director IVT
(reprint from Neth. J. Agric. Sci. 26, 1978, p.1)

Plant breeding aims at the improvement of well defined characters of crops. In his research the breeder is often faced with complicated interactions between genotype and environment. A clearumderstandingof these interactions may be essential for the breeding methods to be used as well as for the interpretation of results.

Efficient research in this field requires that experiments be made under controlled conditions. Accurate control of light, temperature and humidity is only feasible in small isolated rooms and is extremely expensive. However, plant breeding research generally requires a good deal of space as experiments often involve many and rather large plants. Therefore a compromise has to be found between ideal environmental control space and costs.

When in the early 1950's the equipment of the Institute for Horticultural Plant Breeding (IVT) was being considered a phytotron was judged to be indispensable. With 6 temperature controlled glasshouses and 8 growth rooms it **was** expected that this phytotron would meet most needs of our plant breeders. Built in 1953 it was the most expensive gadget of our institute, and proofs of its value for breeding research were anxiously awaited.

Since the 25 years have elapsed. In this period the IVT phytotron, the oldest one in Wageningen, not only functioned very well technically but entirely lived up to our expectations and turned out to be a priceless tool for research. Up to now IVT research workers have already published 95 papers on investigations for which the phytotron was used.

The silver jubilee of our phytotron inspired the staff of IVT to publish another 15 original scientific papers that report the results of phytotron experiments. Dr. L. Smeets, physiologist in charge of our phytotron, took the initiative. The widely different subjects treated in these papers prove once more in how many ways plant breeding can profit by the use of a phytotron when it is used in a creative and effective way.

THE PHYTOTRON OF THE INSTITUTE FOR HORTICULTURAL PLANT BREEDING (IVT), Wageningen, the Netherlands. A REVISION OF PREVIOUS DESCRIPTIONS

L. Smee ts
Institute for Horticultural Plant Breeding (IVT), Wageningen, the Netherlands
Reprint from Neth. J. Xgric. Sci. 26, 1978, pp.8-12.

Introduction

A phytotron may be defined as a laboratory in which the effect of environmental factors, mainly temperature and light, on the growth and development of plants can be studied. The IVT phytotron, which was put into operation in the spring of 1953, was one of the first phytotrons in Europe. Since the first description was published (Braak & Smeets, 1956) the equipment has been continously improved, so that the first description and the one published (Smeets & Braak, 1962) are out of date. A new description is presented in this paper. Data on the accuracy of the environmental control will be published elsewhere.

General design

Fig.2 shows the ground plan of the IVT phytotron. At the south side of the building, along a central corridor, 6 glasshouses (G1-G6) are situated in which both temperature and air humidity are controlled. The houses are kept at constant temperatures of 10, 14, 17, 20, 23 and 26°C , respectively, throughout the year. The air humidity is held at 707 . On the other side of the corridor 8 growth rooms (A-H) are located. In the rooms A-E temperature can be controlled between -10 and +25°C, in F, G, H between + 10 and + 40°C. Light intensities up to 75 W/m2 are possible in A-E, in F, G, H the maximum possible light intensity is 18 W/m2. In all rooms air humidity can be controlled between 50 and 95%.

For culture of plants in vitro an air-cooled room (I) with artificial light and 3 prefab growth caginets (GC1-3), each with a capacity of 1.5m2, are available. In these cabinets the temperature can be controlled between + 10 and + 40°C and the air humidity between 50 and 95%. Light intensities up to 50 W/m2 are possible.

On the north side of the building are the working rooms (R1-R4) and laboratory rooms (L1-L6) for the staff, on the west side the sanitary conveniences (S1-S3) and a room (R5) for the gardeners tending the experimental plants.

Heating is effected by hot water from gas-fired boilers situated in a central boiler house in the experimental garden of the Institute. The hot water enters the building on the east side through room MI in which the circulating pumps are located. The adjacent room M2 contains the pumps for the water supply. Cooling is effected by refrigerating compressors operating with freon-12. Each glasshouse and growth room has its own compresso'. In the basement below LI and R1 are the compressors for the growth rooms A-E and the glasshouses G1-G3. Those for the growth rooms F, G, H are on the ceiling above these rooms, and those for the glasshouses G4-G6 on the ceiling above R5 and SI-S3.

The glasshouses

All 6 glasshouses are 10 m long, 6 m wide and 3.6 m high. Along both sides and at the end there are fixed benches. The remaining space can be used for placing trucks or a bench. To admit as much light as possible into the houses the rafters are thin and the glass panes large.

Fig.3 shows a cross section of one of the glasshouses. Under the rear bench a cooler and a heat (C+H) are fitted, with a ventilator on both sides (VI, V2). The air in the glasshouse is passed over the cooler and the heater by the ventilators and is either cooled or heated and subsequently blown under the side benches which are closed with perforated plates. Through these perforations and through the space between the side benches and the glass the air returns to the glasshouse.

In the outer wall, at the side of the rear bench, there are 3 adjustable openings, one below the rear bench and one below each side bench. Through the opening under the rear bench outside air is introduced and through the other two openings inside air is removed.

In the centre of each glasshouse, 1.2 m above the floor, a thermostat (T) and a hygrostat (H) are fitted in a white painted box which is ventilated continuously.

When the temperature falls below the value sec on the thermostat, hot water starts to circulate through the heatsz. The amount of circulating hot water depends on the decline in temperature. When the temperature rises above the set value, the air is cooled.

Two spray nozzles are fitted below each side bench to humidify the air. When the humidity falls below the value set on the hygrostat, the sprayers are activated. When the humidity rises above the pre-established setting, the cooler is put in operation. As a result the excess of moisture *is* deposited on the cooler as water or ice.

Daylight can be intensified or lengthened by artificial light. For high intensity illumination high-pressure mercury-vapour lamps HPL-N 400 W are used. En each house 20 lamps can be operated. To lengthen the day with low light intensities incandescent lamps can be used. The duration of illumination is controlled by electrically operated time switches.

The growth rooms

The growth rooms A-E 5 m long, 3 m wide and 2.5 m high. The walls and the ceiling are insulated with cork. Fig.4 shows a longitudinal and a cross section of one of these rooms. Under the floor is an air duct in which are fitted a ventilator (V), a heater (HI), a sprayer (S), a cooler (C) and a second heater (H2). The ventilator blows the air into the room through a perforated plate located along one of the side walls. The air is exhausted on the opposite side of the room through a similar perforated plate. Outside air is introduced through PI and inside air is removed through P2. The amounts are regulated by hand-operated dampers (D1, 02).

Each growth room is fitted with 2 thermostats (Ts), one controlling the day and the other the night temperature. The duration of both temperatures is regulated by an electric time switch. The cooler is activated when the temperature is too high, the heater when it is too low.

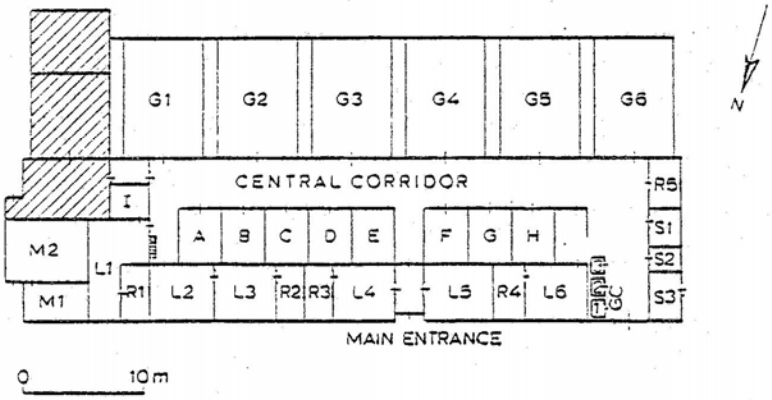

Fig. 2. Ground plan of the IVT phytotron. The hatched part does not belong to the phytotron proper.

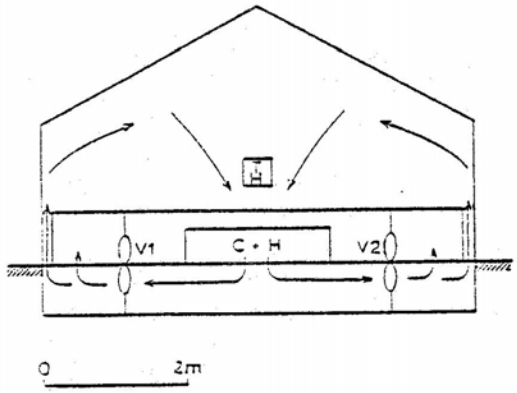

Fig. 3. Cross section of one of the glasshouses G1-G6.

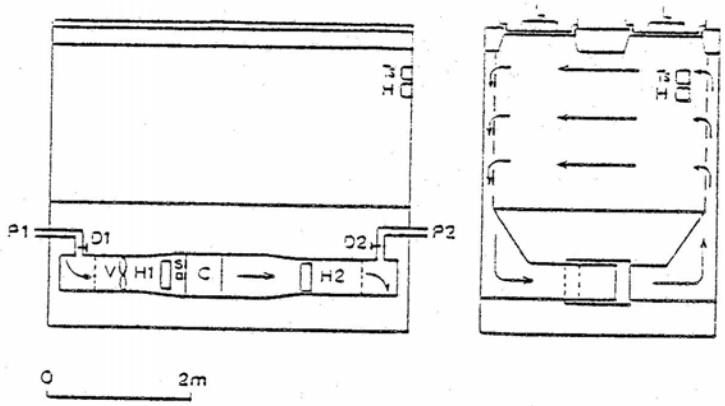

Fig. 4. Longitudinal and cross section of one of the growth rooms A-E.

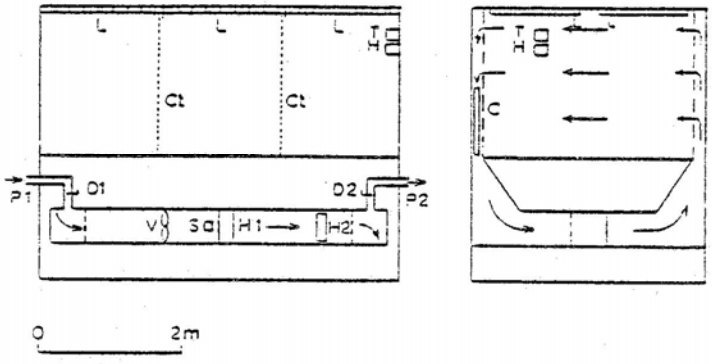

Fig. 5. Longitudinal and cross section of one of the growth rooms F, G, H.

Air humidity is controlled hygrostatically (H) . When the humidity is too low, the air is humified by the sprayer. Simultaneously the heater H1 *is* put into operation to improve the evaporation of the water. When the humidity is too high, the heater H2 is switched on automatically, the temperature rises and the cooler is turned on. The excess of water either condenses or turns to ice an the cooler.

The artificial light consists of mercury ligh and, to improve its spectral composition, of incandescent light. Each room is fitted with 16 high pressure mercury vapour lamps HPL—N 400 W, 8 high-ptessure mercury vapour lamps PHL 700 W and 16 incandescent lamps of 200 W. The lamps (L) are located above two glass windows in the ceiling of the room. When the lamps are burning, cold water runs over the glass panes. To suppress the growth of algae in the water, ultraviolet lamps are fitted along the glass panes. To enable the incandescent light to be also used independently of the mercury light, the duration of both can be controlled separately.

The growth rooms F, G and H are each 5 m long, 3 m wide and 2 m high -Here too the walls and the ceiling are insulated with cork. Fig.5 shows a longitudinal and a cross section of one of these rooms. The air circulation system is the same as in the rooms A-E . In an air duct under the floor are a ventilator (V), a sprayer (S) and 2 heaters (111, and a reheater H2). The cooler (C) *is* situated behind the perforated plate where the air in the room is exhausted.

The temperature is controlled by a thermostat (T) operating the cooler and the heaters.

Air humidity is controlled by a hygrostat (H) which puts the sprayer in operation when the humidity is too Low or the cooler when the humidity. is too high.

On the ceiling of each room 48 fluorescent tubes ILF 40 W/34 De Luxe (L) are fitted. Each room can be divided into 3 compartments by means of curtains (CO. The duration of illumination can be controlled separately in each of the compartments.

References

Braak J. P. & L. Smeets 1956. The phytotron of the Institute of Horticultural Plant Breeding at Wageningen, Netherlands, Euphytica 5, 205-221.

Smeets L. & J. P. Braak, 1962. Das Ventilationssystem der Klimagewachshauser im Phytotron des Institute far Gartnerische Pflanzenzachtung. Wageningen, Niederlande. In: R. Knapp (Ed.), Untersuohung der Pflanzen- Entwicklung enter klimatisch kontrollierten Bedingungen. Einrichtungen und Arbeitsergebnisse in Phytotronen, klimatisierten Gewachshausern, Klimakammern und ahnlichen Anlagen. Eugen Ulmer, Stuttgart, p.7-11.

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VII. B1OTRON. MANUAL FOR INVESTIGATORS

Editor's Note. Professor T. T. Kozlowski, the Director of Madison Biotron (USA) send us the Manual for investigators with following comments:

"I enclose a copy of our new Biotron Manual which explains that the Biotron is and how it operates".

"This manual is an outgrowth of more than 10 years of experience in Biotron operation. We have made a sincere effort to outline procedures that will enable us to operate the Biotron efficiently and, within the limits of our resources, to offer the best possible support to investigators. The procedures outlined, some of which are new, were given considerable thought and have been approved by the Biotron Committee. As we acquire more experience, we expect to make additions and alterations in the Manual. With that view in mind we welcome your written comments and suggestions".

"We especially urge new investigators to read the manual carefully. We hope it will be helpful in both planning and carrying out research in the Biotron".

From this Manual we reprint certain passages specially related to plant. Those readers who desire more informations or gave comments or suggestions please write to: Biotron-University of Wisconsin- 2115 Observatory Drive- Madison - Wisc. 53706 USA.

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What we are....

The Biotron is a system of controlled environment facilities designed and operated as a tool for investigating relationships between plants or animals and their environment.

Most of the equipment in the Biotron is dedicated to the production of specific "weather" conditions within the experimental rooms or chambers. We can routinely control several physical parameters of the environment including temperature, light quality and intensity, daylength, and relative humidity. However, we are not limited to controlling these variables. Indeed, with an investment of imagination of the investigator and the Biotron staff, we frequently can extend the programmed part of the environment into far more exotic and exciting areas …We cannot pretend to meet all possible environmental requirements of investigators but we would be pleased to study requests and proposals.

The Biotron is located at and managed by the University of Wisconsin - Madison, but it is a facility available toscientists from anywhere that need space in which to ?rogram and simulate diurnal and seasonal regimes, to maintain a very constant environment to insure uniformity, or to vary one or more climatic factors in a predictable manner.

No particular discipline or group within the broad area of biological sciences has any priority or space committed solely to it in the Biotron. ApplicatiOns for use of space or facilities in the Biotron are first reviewed by the Biotron staff so the investigator can be assured that it is technically feassible to employ the facility, and then evaluated by the Biotron committee for scientific merit, experimental design, and need for the facility.

Research that depends on the sophisticated capabilities of the Biotron will be given priority over research that depends *less* on these capabilities.

Biotron space for approved projects is allocated for the duration of an experiment only and normally not for more than one year. Projects are sometimes approved for extension beyond one year following submission of a new application form well before the expiration period.

The Biotron does not normally do research for the investigator but rather provides a sophisticated aid in the form of space, equipment, and operational skills.

AT WE DO FOR INVESTIGATORS .....

We try to provide the best facility, both in equipment and operation, that our budget will permit. Investigators should check with us before starting a formal request for space or funding to learn of the possibilities and limitations of our facility and personnel. We cannot match your skills in the area of your speciality but we may be able to suggest more efficient of effective use of our rooms and machinery.

In trying to provide a sate and sensioie Level or operation, anu UL **suulLa-tion** and isolation of all projects, we normally assume responsibility for providing pots, plant media, etc. We also do routine feeding, watering, and waste disposal.

As part of the evaluation of your application for space, the Biotron staff will be glad to confer with you about details of the environmental conditions that you have outlined and requestol. The temperature and humidity sensors in your room are scanned once every 30 minutes and the data recorded. A copy of the data is available to you on request and is kept on file for future reference.

Light intensity levels are measured at the beginning of each project and at 30-day intervals thereafter in units appropriate to the organism under test. These measurements are made at specific reference points and are intended both for maintenance purposes and to provide the investigator with knowledge of the light intensities during the investigation. Typical spectral distribution curves are available but are not routinely made for individual projects or rooms.

The accuracy of sensors and loggers is checked routinely. However, there is always the possibility of drift or failure. Our control and data systems are designed for limits of tolerance of -1- 0.5°C and 5% relative humidity. Maintenance and calibration schedules are based on these tolerances.

LN ADVANCE ....

As part of the normal services covered by the charge to users, the Biotron staff will set up any reasonable complement of our standard cages, racks, pots, enclosures, etc./ prior to occupancy. A sketch and specific instructions should be submitted with your request for space and confirmed before arrival. Modifications should be cleared with the Biotron office. Certain limits may be placed on the number or cages or carts in any room to conform with regulations on animal care and to allow for convenient movement of personnel and equipment.

If desired, pots will be filled with soil or other growing medium and wetted or an initial sec of bedding, pan covers or litter, food, water, etc. will be ready at the time of occupancy; providing that the Biotron office has been notified in advance and that the material requestais part of our normal stock.

Please note that inspection, isolation or fumigation of incoming organisms may be required to protect projects already underway. You will be notified about these requirements by Biotron personnel or by the appropriate committee or agency.

ARRIVAL ....

Unless special arrangements have been made previously, your arrival time should be scheduled so as to permit completion of the moving, caging, potting, preparetion, etc. during normal civil service working hours. (0745-1145, 1230-1630, Monday to Friday). Since a limited caretaker staff is on duty weekends and holidays, proper handling of incoming projects *is* difficult on those day s.

Experimental plants that are brought into the Biotron must be fumigated for 48 hours in the Biotron fumigation room before they are taken to research rooms. The investigator should make specific arrangement with Biotron supervisory personnel for delivery and receipt of plants during normal working hours.

Soils brought into the Biotron should be sterilized. Arrangements can be made with Biotron supervisory personnel to have this done in the Biotron.

PLANT CARE.....

The Biotron has 16 standard plant growth rooms, 4 small growth rooms, 2 large nurseries, a room with fumigation chambers, a high light intensity room, one two story room, a wind tunnel, and a crossed gradients room; these together with small cabinets give the investigator a great variety of spaces and conditions.

Routine care is provided at no extra charge. Automatic nutrient and watering systems are available along with a selection of plant containers, carts, potting media and other basic plant care needs.

To guard against the danger of disease or pest transmission, incoming plant material or sail may require fumigation or sterilization before entry to the Biotron is permitted. Contact the Biotron supervisory staff before the start of your project for details.

POTS ....

The Biotron maintains a stock of standard containers which were chosen to give optimum use of the trays on the plant carts. Plastic pots are normally in stock in ranges from 2 1/4 "to 8" and small quantities of larger containers are maintained. A variety of plastic and fiberglass tanks to fit on one or more plant carts is available.

Except as part of long range funding and expansion plans, the Biotron will not purchase or construct special containers to meet your specific needs. Equipment on hand is available on a first come - first serve basis, and typically many containers of a given size are in use on current projects. Please indicate the sizes and quantities needed for your project on your application form so that we can advise you about availability from our stock.

CARTS.....

Several types of plant carts are available from the Biotron stock for the convenience of the investigator.

The standard plant carts have perforated shelves which are adjustable in increments of 10 cm from 65 cm to 135 cm below the light loft barrier. (Lamps are 25 cm above the barrier).

The exterior dimensions of the carts are approximately 76 cm x 76 cm. Carts are equipped with casters and have support rails on two sides.

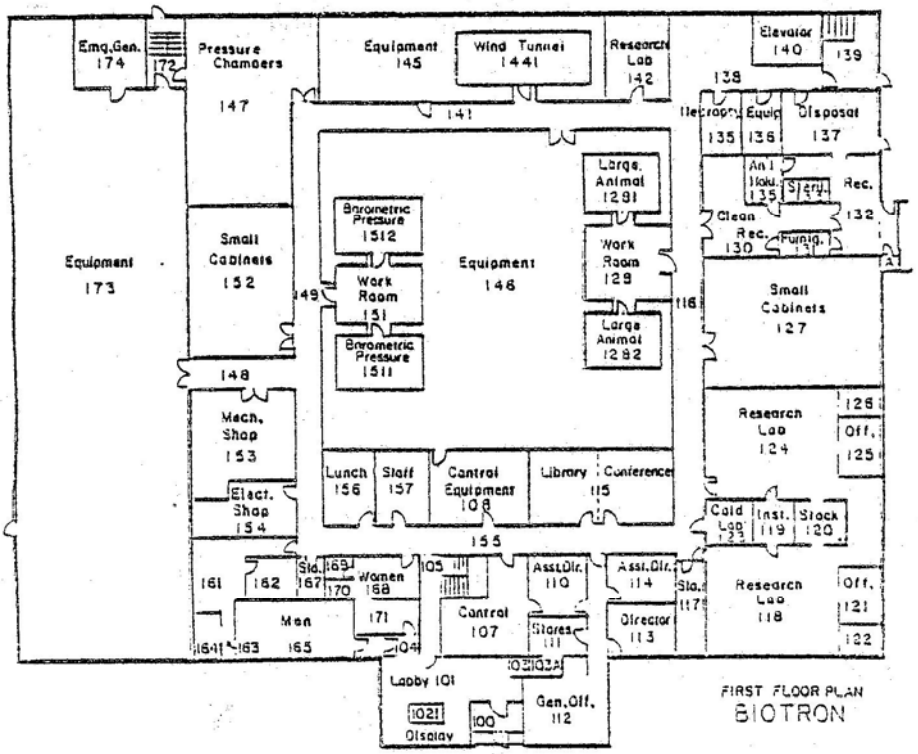
The trays (measured inside of mounting lips) are 67 cm x 71 cm. Similar trays are used in the small cabinets.

Check with the Biotron staff about special carts or stands in stocks. Unless agreed to as part of the original application, benches or carts will not be constructed to meet exceptional needs of any project.

Cart PLACEMENT ...

While carts or supports can be arranged differently than shown above, we suggest that you employ this placement since it has proven to be a satisfactory compromise between accessibility, room loading, air flow, and light distribution.

Adjustments of louvers, vents, and sensing points are made to optimize evenness of control within the space most frequently occupied by plants.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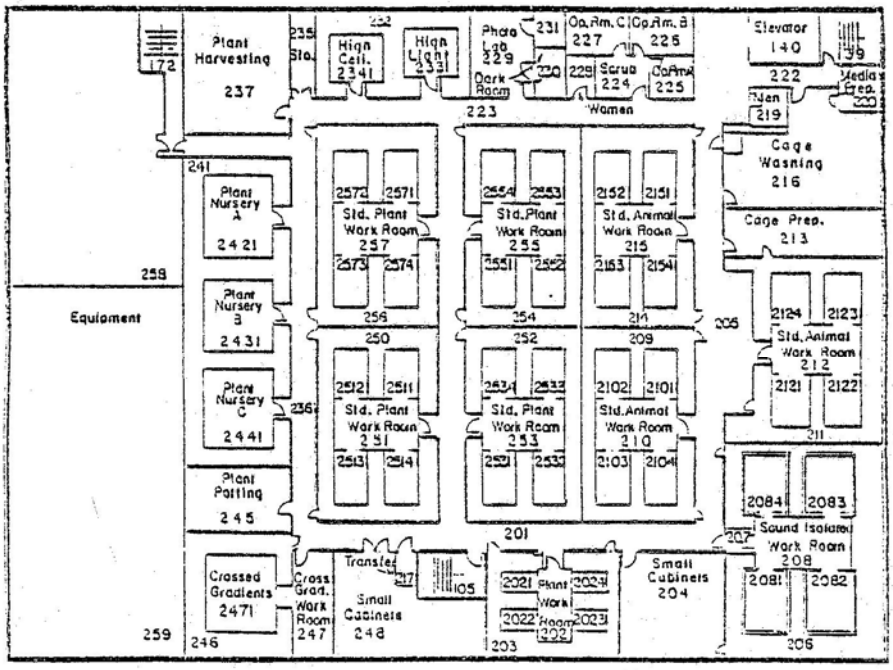
FIRST FLOOR PLAN
BIOTRON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WATERING AND FERTILIZING.....

Unless specifically requested and approved at the time the application for space is made, the Biotron reserves the choice of hand or automatic watering and fertilizing of plants.

Automatic systems can be arranged to provide mineral nutrients in solution for any or all 5-minute intervals throughout the day. Flow rates can be adjusted to any value obtained from the standard plastic tube watering systems, typically 10 ml/min and up.

Changeover from nutrient solution to water can be made automatically on specific hours or days.

Hand watering schedules by Biotron staff cannot be accomodated before 0800 or after 1500 hours local time. If a displaced daylight schedule is required because of cooling or power restrictions, hand watering schedules will be limited to those daylight hours falling within the above time bracket.

Demineralized water is available in the plant growth rooms and work rooms, and is used in the automatic *systems.* The Biotron will supply standard half-strength Hoagland's solution.

Departures from this procedure are the sole responsibility of the individual investigator. The design, construction, and operation of special mechanical systems will considered part of the experimental work associated with the project itself. If special nutrient solutions are needed for an experiment they must *be* made available to our plant caretakers in a mixture ready for application. Our caretakers will not make dilutions, measure pH, or make chemical measurements.

ROOM SPECIFICATIONS ....

Following approval of your application for space, the actual assignment of rooms or chambers is made by the Biotron administrative staff, and always with the option of providing nearly equivalent space should conflicts in schedules or mechanical problems arise.

?lease check with the Biotron administrative or engineering staff if there are any questions about the limits or capabilities of any of the rooms or equipment. More detailed specifications than those given in the table are available on request. Sketches or floor plans are typical and if space or placement of apparatus is extremely critical to your project, please check for variations in fluid or electrical outlets, protrusions into the rooms with utility valves or for minor changes in dimensions.

Engineering and maintenance efforts are directed to holding conditions within the "envelope" occupied by the cages or carts shown in the room sketches as constant as possible. While in some cases it may be possible or desirable to use other than these areas, the Biotron will not readjust vents, louvers, or lights in an effort to extend stable or uniform conditions beyond those normally controlled. Temperature or light profiles that are shown in various technical specifications are typical but may vary considerably with your particular arrangement of containers or containments. Air flows and other adjustments are made on the basis of the typical situations and are checked periodically. Further measurement of the microclimate experienced by the individual experimental organisms are considered to be part of the normal experimental procedure and are not normally made by the Biotron staff.

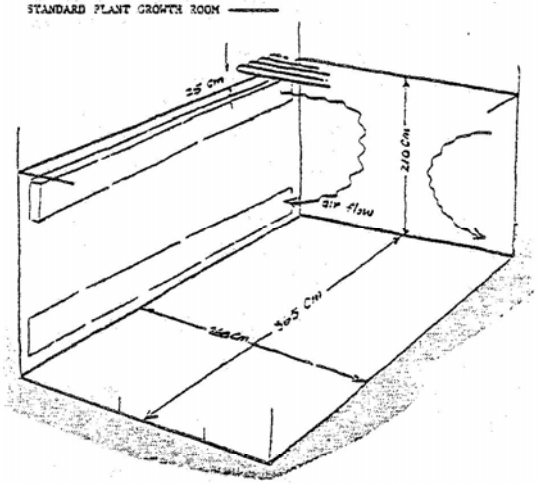
TYPE OF ROOM	NO. OF ROOMS	DIMENSIONS (FT)	TEMPERATURE (°C)	HUMIDITY % RH	LIGHT	SPECIAL FEATURES
Animal (std)	4	8.5x12	+10 to +45	15 to 90	A	
" "	4	8.5x12	+5 to +45	"	A	
" "	4	8.5x12	-15 to +45	"	A	
Animal (large)	1	12x17	+5 to +45	"	A	
" "	1	12x17	-15 to +45	"	A	
Plant (small)	2	4x8.5	+10 to +45	"	P	Radiant cooling
" "	2	4x8.5	+5 to +45	"	P	" "
Plant (std)	10	8.5x12	+10 to +45	"	P	1 room with S
" "	5	8.5x12	+5 to +45	"	P	
" "	1	8.5x12	-15 to +45	"	P	
Plant (nursery)	2	16x17	+10 to +35	"	P	
Crossed Gradients	1	16x16.5	+5 to +45	"	P	$\Delta T=15^{\circ}C$, Light 10:1
High Light	1	9x12.5	+5 to +45	"	S	
High Ceiling	1	9.5x13	+5 to +45	"	S	Adj. 6' to 11'
Sound Isolated	4	8x12	+5 to +45	"	A	1 with RF shield.
Barometric press.	2	12.5x17	-15 to +45	"	S	690 mm to 790 mm
Wind tunnel	1	9.5x31	-15 to +45	"	P	5 sect. demountable
Fumigation chambers	various - request technical data				P	
Glove boxes	"	"	"	"	P/A	
Cabinets (animal)	20	2x2.5,2.5x8	+10 to +35	"	A	Request details
" (plant)	12	2.5x4,2.5x8	+10 to +35	20 to 90	P	" "
Tank (large)	1	6Wx12LX4H	+20 to +40		A	
Tanks (small)	14	various to 320 gals - request details				
Hyperbaric chamber (3 section)	1	6.5Dx9L	+10 to +30	"	A	-7.3 to 450 psig
		6.5Dx7L	"	"	A	" " "
		6.5Dx4L	"	"	A	" " "
Altitude (2 section)	1	7Dx23L	"	"	A	-12 to 0 psig
		7Dx6L	"	"	A	" " "
Altitude	1	5Dx4L	"	"	A	-12 to +2 psig
Altitude	1	2x2.5x3	-	-	-	-12 to 0 psig

P = lighting suitable for plant growth (760 uE/M^2, approx. 3900 fc)

A = lighting suitable for animal housing, nominally to 100 fc

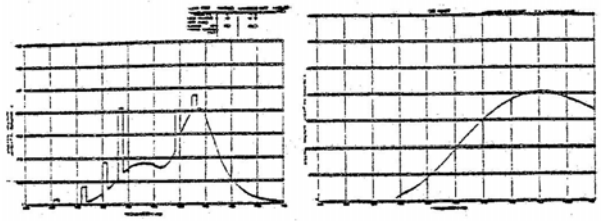
S = Special-high intensity or different spectral distribution. Request details.

STANDARD PLANT GROWTH ROOM



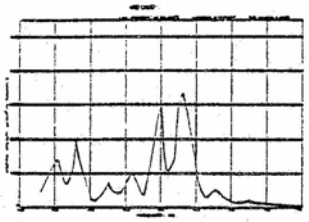
Each room is equipped with a floor drain, hot and cold city water, demineralized water, two duplex 120 V. electrical outlets (20 A. total), one 3 phase 208/120 V. outlet (20 A. per phase - shared with other rooms in the suite) and fittings to permit connection of cooling coils in tanks to the chilled brine system. 80 psi compressed air is available in the work room and a regulator and piping will be provided by the Biotron if air is required in the growth room. A 10 cm diameter sleeve extends thru the front wall of the room to permit passage of fluid, air, or electrical lines to the work room. The investigator may use this sleeve to connect portable apparatus.

The following spectral distribution curves are typical for light sources used in the Biotron. As indicated, they are taken from manufacturer's data or from measurements taken in the Biotron:

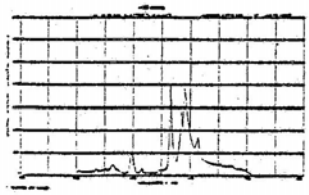


Cool white fluorescent

Tungsten incandescent

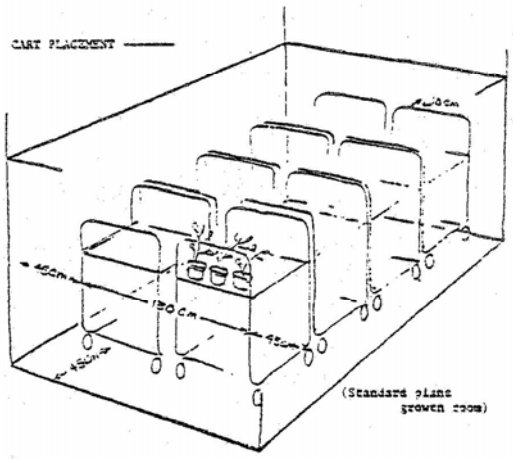


Metal halide vapor



Sodium vapor

CART PLACEMENT



(Standard plant growth room)

While carts or supports can be arranged differently than shown above, we suggest that you employ this placement since it has proven to be a satisfactory compromise between accessibility, room loading, air flow, and light distribution.

Adjustments of louvers, vents, and sensing points are made to optimize evenness of control within the space most frequently occupied by plants in the above arrangement.

Please check with the Biotron staff before planning cart positions different than those shown above.

STANDARD PLANT GROWTH ROOM.....

Each room is equipped with a floor drain, hot and cold city water, demineralized water, two duplex 120 V. electrical outlets (20 A. Total) , one 3 phase 208/120 V. outlet (20 A. per phase- shared with other rooms in the suite) and fittings to permit connection of cooling coils in tanks to the chilled brine system. 80 psi compressed air is available in the work room and a regulator and piping will *be* provided by the Biotron if air is required in the growth room. A 10 cm diameter sleeve extends thru the front wall of the room to permit passage of fluid, air, or electrical lines to the work room. The investigator may use this sleeve to connect portable apparatus.

LAMPS AND LIGHTING .....

The majority of the Biotron rooms are lighted by "cool-white" fluorescent and standard incandescent lamps. A few are equipped with Xenon, high intensity discharge or other special lighting units.

Light levels in plant rooms may be varied in increments of 10% of the tubes (spaced evenly across the room). The incandescent lamps may be dimmed by the reduction of the applied voltage in steps of 100%, 60%, and 20% by the normal program and controllers. To meet special requirements, a manual controller is available to set the voltage on these lamps at any desired level.

Fluorescent lamps in the plant rooms are replaced on the following basis: the light level is checked at four specific locations in the room prior to the start of a project, with lamps being replaced as required to bring the level at 30 cm below the barrier to 760 microeinsteins per square meter per second. (Approximately 3900 fc or 42000 lux) Measurements are made at designated spots on the barrier every 30 days. If the average output has decreased by more than 8.0% *of* the initial value, lamps are replaced to return the output to the initial conditions.

Experimentation on higher intensity and more efficient light sources continues at the Biotron.

We will attempt to stay at the "state of the art" and to keep you informed about new lamps as they are installed and tested.

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VIII. CLIMATE LABORATORY NEWSLETTER

No 10 - April 1979

Here we reproduce some informations of this New Zealand review sending to us by Dr. I. J. Warrington, leader of Biological services group and Dr. R. W. Robotham, leader of Technical Systems. Requests for more informations should be addressed to Plant Physiology Division. DSIR. Palmerston North, New Zealand.

Controlled environment room use

The total occupancy of the Laboratory was 87% and the number of projects handled during the 1978-79 period was 31. This is generally the same as for the previous two years. The 10 to 15 percent difference between actual room use and total (100 percent) occupancy is due to two main factors. Firstly, the specialist rooms such as the low temperature frost rooms and the high Light room are not used year round but are

included in the table calculations. Secondly, some of our users fail to schedule their plant supply precisely enough to match room availability and others have complete failures in the propagation and seedling establishment stages of their projects. The latter problem is best solved by researchers using the Plant Physiology Division's plant nursery and glasshouse facilities to raise their material.

Visitors

The Laboratory hosted over 1 000 visitors during the previous L2 months. Included were several pre-and post-Congress tours of scientists attending the 20th International Horticultural Congress in Sydney, Australia. Many individuals, including several on the American Society for Horticultural Science's Growth Chamber Committee also visited the Laboratory.

New facilities and equipment

NUTRIENT ROOM

The Technical Systems Group has completed the reconstruction and maintenance of the central nutrient make-up room. This has been completely renewed and the pumps overhauled and recalibrated.

FROST ROOMS

The Technical Systems Group has completed the installation of the new compressor for room 23 (frost room). Previously the two frost rooms had dissimilar refrigeration systems and their operating characteristics were sufficiently different to induce detectible differences in plant response when identical programs were operated. The modifications should remove that problem.

SULPHUR DIOXIDE CABINET

The cabinet and instrumentation were completed in March and several preliminary exposure treatments have been carried out. A detailed program will now be got underway for the Forest Research Institute to investigate the effects of sulphur dioxide on Pinus radiata growth and development. This research is part of a program to assess the possible effects of SO_2 and H_2S emission from the proposed Broadlands geothermal power development.

Other points of significance are:

. the root washing facilities are being shifted to a permanent location in the reach-in growth cabinet building. The main new feature is the provision of Large waste collection trolleys which will be held outside the building and will be easily removed for waste disposal.

. the Biological Services Group will be purchasing a wide-bed leaf area meter to improve on the capabilities of existing equipment.

. the equipment for collection of biological/environmental data is under review and proposals for new, replacement data logging facilities will be considered.

. the Technical Systems. Group has purchased part of a new system to replace the aged control information and monitoring (alarm) system on the central control system. Plans are underway to investigate the replacement of the control and program parts of the system.

Climate Room Allocation Committee

The Allocation Committee is advisory to the Director-General of DSIR and has the following responsibilities:

1. to allocate annually the controlled environment space available to the four main user groups: i. E. DSIR, MAF, Forest Service and Universities.

2. To comment on the quality and type of service available. Far example, the Committee recently recommended the development of the SO_2 facilities.

INDIVIDUAL REPRESENTATIVE RESPONSIBILITIES

Each individual repreSentative on the Committee also has the responsibility to-

(a) approve all of the projects from his department that are to proceed in the Climate Laboratory,

and, (b) put the projects into a priority order if space limits a project from starting when required by the experimenter. In practice, projects for the Laboratory can usually be scheduled on a "first come - first served" oasis and the average waiting time is about 4 months.

Climate Laboratory projects

A. Plant Physiology:

Exp.199. P. Jameson and J. A. Mc Wha. Cytnkinin levels during stolon and tuber development in Solanum andigena.

Exp.202. I. R. Brooking. Effect of gorin 10 Gene (Rhtz) on inflorescence development in winter wheat.

Exp.189. K. J. Bennett, H. A. Eagles and A. K. Hardacre. Drought tolerance in maize genotypes.

Exp.190. A. K. Hardacre, J. T. Christeller and W. A. Laing. Effects of elevated $C0_1$ on plant growth.

Exp. L98. R. A. Norton and I. J. Warrington. Effect of intensity and duration of Lighting an growth and development of selected horticultural species.

B. Agronomy:

Exp.169. E. T. Kanemasu, I. J. Warrington and C. A. Stawart. A study of the leaf and reproductive development of corn (Zee mays): responses to temperature.

Exp.186. Mc Pherson and I. J. Warrington. Daylength and temperature effects on time to flowering of pigeon pea (Cajanus Cajan).

Exp.197. A. Hart. Analysis of the phosphorus response of four pastoral legumes.

Exp.194. J. A. Baars. A determination of the seasonal relationship between stage of growth and daily growth rate for Ryegrass white clover swards in the Waikoto.

Exp.192. L. J. Davies and B. J. Forde. Effects of prolonged low temperature treatment and frosting on the survival of tropical grasses.

C. Forestry :

Exp.200. D. A. Rook and al. Stomatal plug formation in Pinus radiate and its effect on rates of gaseous exchange.

Exp.201. D. A. Rook, D. G. Holden and M. Wilcox. Variation in frost tolerance of Eucalyptus fastigata D and M.

Exp.193. I. L. Sarton and W. Silvester. Effect of temperature an the survival and growth of Kauri (Agathis australis).

Exp.191. I. J. Warrington. A study of the effects of rate of freezing, rate of thawing, duration of freezing and their interaction with the degree of low temperature on damage to radiata pine seedlings.

D. Horticulture:

Exp.195. R. A. J. White and G. N. J. Goldie. Observations of the effect of low temperature on bud development and flowering in Leptospermum spp.

Exp.208. P. Ragan and M. A. Nichols. The effect of temperature on the maturity characteristics of garden pea.

E. Plant Breeding and genetics: Exp.188. 207-210 and 211. H. A. Eagles and A. J.

Hardacre. Cool tolerance of maize.

Exp.203. P. W. Woods, I. L. Gordon and E. Roberts. Pollination patterns in safflower Carthamus tinctorius.

Exp.204. C. R. Slack. Selection of high oil content, Botrytis resistant safflower lines.

Exp.205. G. K. Pandey. Graft transformation in trifolium.

F. Air pollution:

Exp.196. R. J. Cameron and al. Effects of sulphur dioxide on Pinus radiata.

G. General:

Exp.206. S. A. Espie and G. A. Manderson. Effects of relative humidity on the drying rate and activity of Baker's yeast.

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IX. EUROPEAN SOCIETY OF NUCLEAR METHODS IN AGRIODLTURE.(E. S. N.4

Editor's Note. The Secretariat of ESNA has kindly sent us two Newsletters from which reprint table of contents. Those readers who desire more informations please write to: Secretariat of ESNA. P. O. Box 48. Wageningen, The Netherlands.

A. Newsletter n°10. September 1978. Contents:

Organization and administration of the Newsletter.

1. Labelling techniques.
1.1. General techniques,
1.1.1. Pawlak M. and Nalborczyk E.,Equipment for simultaneous measurement of $^{14}CO_2$, $^{12}CO2$ and water vapour in plant gas exchange studies.

2. Radiation techniques.
2.2. Measurement of thickness, density, levels, composition etc. with the help of X, β, γ, and neutron radiations.
2.2.1. Schitzler H. P. Diagnostic of dry rot in living trees,
2.3. Activation analysis.
2.3.1. Manoukas A. G. and Grimanis A. Application of neutron activation analysis in determing the mineral contents of the olive fruit fly and its food.

3. Various techniques.
3.1. Charnel A. Study of the localisation of foliar applied copper by means of an ionic analyser and a laser probe mass spectrograph.
3.2. Middelboe V. Optic emission of 12C/ ^{13}C ratios.

B. ESNA Newsletter. Working group nuclear techniques in the study of Soil-Plant relations. News from the meeting in Brno Czechoslovakia 1978. Contents:

Frissel M. J. (The Netherlands)
Introduction, long term uptake of 15N (Abstract this issue)

Filipovic R., S. Stojanovic and S. Simic (Yugoslavia)
The fate of nitrogen fertilizer applied in field conditions. (Copy this issue).

KraloVa, Marie, K. Drazdak and J. Kubat (Czechoslovakia)
Transformation of 15KNO3 added into soils in the presence of glucose. (Abstract this issue)

Slowik K. and D. Swietlik (Poland)
15N in fruit tree nutrition. (Abstract this issue)

Jakovljevic M., M. Ptrovic and Dj. Jelenic (Yugoslavia)
The influence of nitrogen fertilization on the changes of soil nitrogen availability. (Copy this issue)

Skarlou V., E. P. Papanicolaou, S. Nobeli and Katranis (Greece)
Fertilizer utilization studies in cotton using 15N and 32P labelled fertilizers. (Copy this issue)

Kubat J., Marie Kralova, B. Nova, K. Drazdak and F. Kysela (Czechoslovakia)
The influence of fluctuating temperature on the 14C-glucose decomposition in soil. (Abstract this issue)

Knight A. R. (United Kingdom)
Some remarks on the production of isotopically labelled plant material. Address of author: Macauly Institute for Soil Research, Craigie buckler, Aberdeen, U. K.

Raunold E. Nitrogen balance of sugar beets. (Copy this issue)

Ratkovic S. and G. Bacic. A proton magnetic resonance study of Mn uptake by plant root using Mn++ ions as a paramagnetic probe. (Abstract this issue.

Filipovic R., Study of the transformation of 15NH4, 15NO3 in soil (without plants). (Copy in this issue).

Paltineanu I. C., R. Paltineanu, I. Apostol, M. A. Sanjrani. Neutron method use in studies of drip, sprinkler and furrow irrigation of field crops (this issue).

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X THE DETERMINATION OF THE TOTAL ROOT LENGTH OF A SAMPLE BY AN AUTOMATIC METHOD

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Summary

The difficulty of describing the root system has severely hampered research on this organ. In this paper we outline the construction and *use* of an instrument which can, in less than 3 minutes, accurately determine root lengths of up to 50 m. The instrument incorporates novel optics which greatly enhances resolution and depth of field.

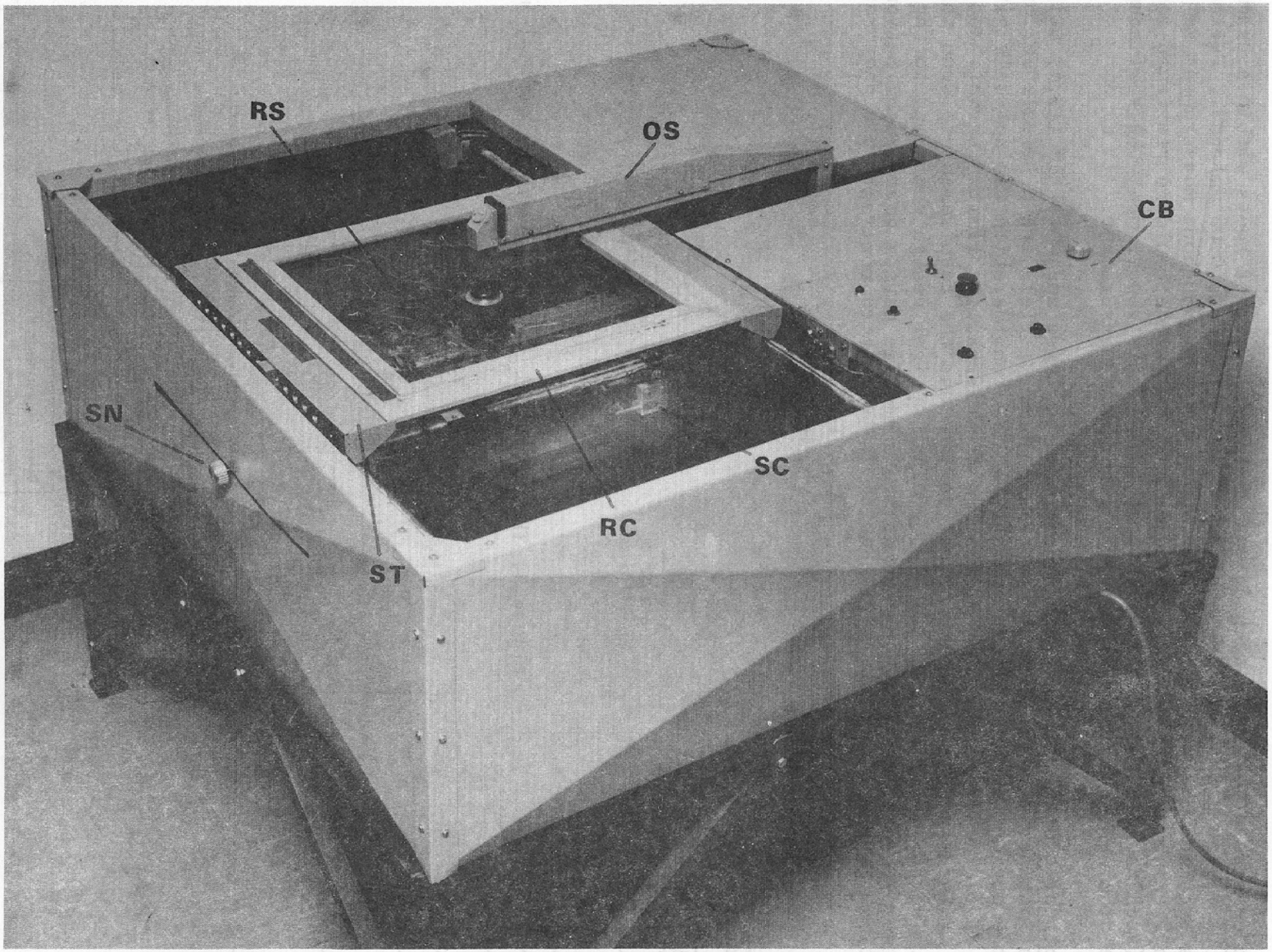
Introduction

Estimation of root length by direct measurement is normally too tedious and time consuming to be practicable. An alternative method using a line intersect principle was suggested by Newman (1966). The method involves counting the number of intersections between roots which are spread on a flat surface, and a set of superimposed straight lines.

Even though Newman's method and its Various modifications have been found to be both accurate and time saving (Newman 1966; Reicosky, Killington and Peters 1970; Tennant 1975) all visual techniques tend to be tedious. With this in mind, Rowse and Phillips (1974) developed an instrument for estimating the root length of a sample. The instrument was based on the line intersection principle and utilized a photoelectric method to count intersections. A limited amount of data for roots showed that the machine gave a good estimate of root length up to the maximum length tried (12.5 m).

The development of a root length machine is reported here that is *also* based on the intersection principle and utilizes an opto-electronic counter. However, the presentation of the roots, the optical design and the method of scanning are different from that of Rowse and Phillips (1974). Furthermore, the machine has a much greater capacity to measure long samples than other methods and was calibrated in detail up to 50 m of roots.

EXPLANATION OF PLATE: The root length machine, CB, the control box; ST, the root sample table; SN, the split-nut mechanism to move the sample along; OS, the optical scanner arm; SC, solenoid-activated clutches to move the scanner arm; RS, the root sample; RC, the glass-bottomed root container.


RS
OS
CB
SN
SC
RC
ST

A visual method of root length based on Newman's technique and similar to the modifications suggested by Evans 0970) was used as a comparison with the machine.

Description of the Machine

Design considerations. The machine was designed to detect roots within a diameter range of 0.1 to 3.0 mm and to resolve two adjacent roots 0.05 mm apart. Furthermore it was required that the root tissue remain turgid throughout measurement so that its physical properties remain unaltered and the sample could be retrieved for other uses (such as hormone analysis). To comply with this requirement the root sample, unlike other methods, remains in water throughout measurement.

The optical system. The instrument developed by Rowse and Phillips (1974) utilized conventional linear optics where focus and depth of field are critical. In formulating the optical design for the present machine consideration was not only given to the depth of field and resolution but also to the diffractive limits (Garwoli and Hughes 1968) of both the condensor and objective lens and the requirement to scan through water. The choice of lenses, light source and optical design conformed to the requirements of the detection system and at the same time gave a good approximation to an optical Fourier Transform giving an adequate pattern contrast at a photo-diode

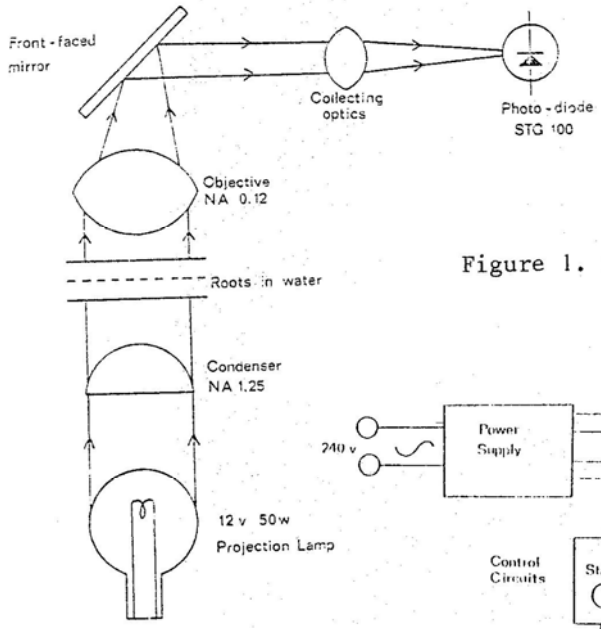


Figure 1. The essential components of the optical system

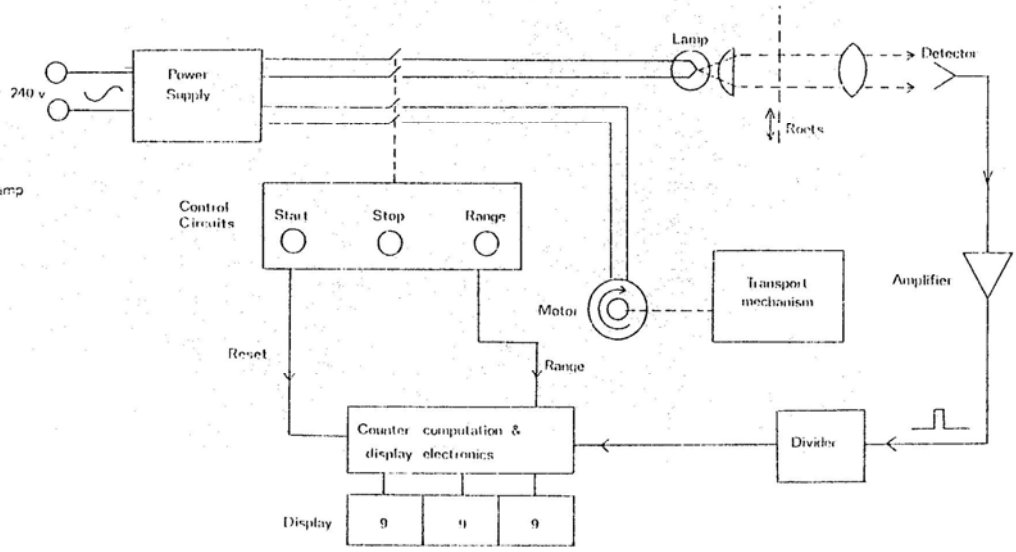


Figure 2. Block diagram of important components.

(STG 100). Thus detection is based on light patterns that are independent of the size and orientation of the object (roots). As a result the effective depth of field was increased to approximately 5 mm. By using collimated light passing normal to the surface of the water aberrations due to reflection, diffraction and wave motion are avoided.

The essential components of the optical system are shown diagrammatically in Figure I.

Full details of the principles and design of the optics will be published at a later data (Garwoli 1979).

Electronic and control systems. The important components of the root machine are shown in the block diagram (Fig.2).

A high quality photo—diode (STG 100) forms the front end of the detector. High optical gain is achieved by placing an effective 1. 3 M ohm resistor in series with the photo—diode. To prevent Loading, the diode output is voltage-followed by a field effect transistor. This is further amplified by a transistor (minimum current gain of 250) and an operational amplifier. To make the output independent of the root parameters a voltage comparator is used. This produces approximately 12 volts pulse if root presence is detected.

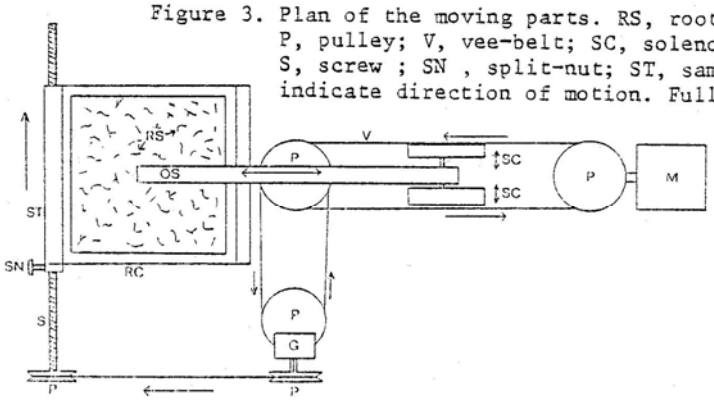
The processing system receives the signal from the optical detector via inhibit circuits and sums to memory (volatile, consisting of a dividor bank). This in turn activates a three digit light emitting diode display mounted on the control box and wired to a range switch. allowing a display of root length directly in metres.

The moving parts. A diagram of the plan of the moving parts is shown in Figure 3 and the root machine itself with important components marked is shown in Plate I. The locomotive force for the whole machine comes from a motor coupled through a 90:1 reduction gearbox. This motor, through a set of pulleys and a gearbox, drives a screw which in turn translates the root sample table (ST). The table is coupled to the screw through a split cut (SN) enabling a reset facility.

The same motor drives a Vee—belt between two pulleys at constant speed_ The optical scanner (OM is mounted so as to ride with the belt. Solenoid—activated clutches (SC) alternatively grip onto opposite sides of the belt imparting a reciprocating motion to the scanner. Thus immediately after the change of direction the scanner traverses the root sample (RS) at constant velocity.

The combined motion of the scanner and the translation of the root sample table produces a zig—zag scanning pattern which is essentially two sets of inclined parallel lines.

Figure 3. Plan of the moving parts. RS, root sample; OS, Optical scanner; M: motor; P, pulley; V, vee-belt; SC, solenoid activated clutch; G, gear-box; S, screw ; SN , split-nut; ST, sample table; RC, root container. Arrows indicate direction of motion. Full explanation contained in the text.



The starting or stopping of the counting mechanism is achieved by microswitches that are activated by the translation of the root sample table. The optical scanner which moves backwards and forwards across the sample has limit switches designed to avoid the possibility of counting the edge of the root container (RC).

Measuring the Roots

Preparation and presentation of the sample. Washed tree roots up to 2 mm diameter were used for all measurements. The diameter distribution of the roots was not quantitatively determined, however, all root samples contained a typical range of root diameters (0.1 to 2.0 mm). After direct measurement of each sample on centimetre graph paper the roots were cut into small pieces and suspended in 400 ml of water (depth of 3 mm) in a glass bottomed tray (375 x 375 x 10 mm). The roots were teased apart and spread out uniformly and remained submerged in water throughout the measurement.

As a comparison with the machine root length was also determined using a visual grid method based on Newman's technique (Goubran and Richards 1979).

Practical tests. For the purpose of calibration ten 5 m samples were measured and combined consecutively up to 50 m.

Each sample was retrieved and redistributed three times. For the grid method the time taken to complete the measurement was recorded on each occasion. For the root machine each scan took 3 minutes.

The calibration curves for both the modified grid method and the root machine are shown in figure 4. Values for the actual length were taken as those measured directly on graph paper. Each point on the graph represents the average of three readings on the same, but rearranged, sample. The graph shows that the root machine

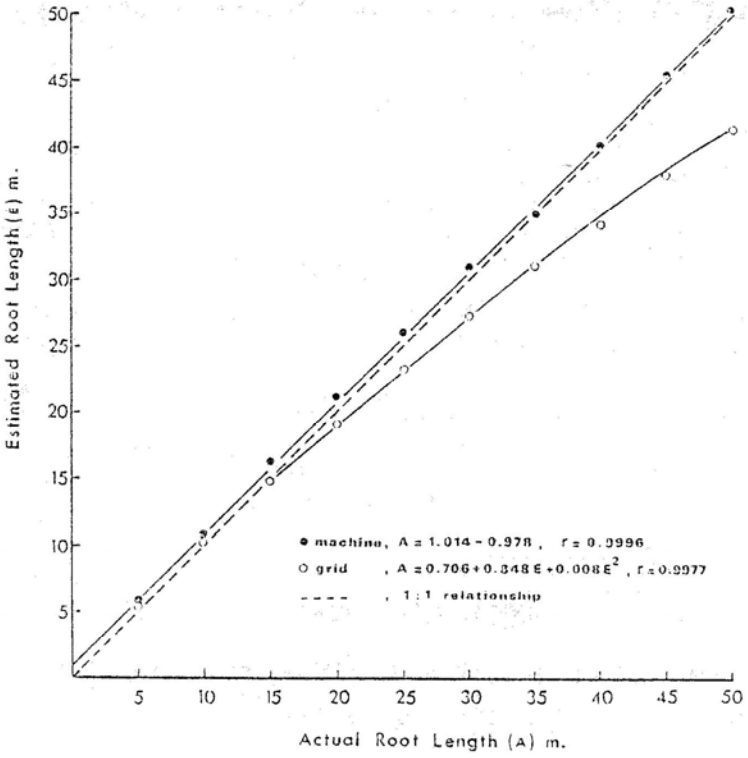


Figure 4. The relationship between actual (A) and estimated (E) root length for each method.

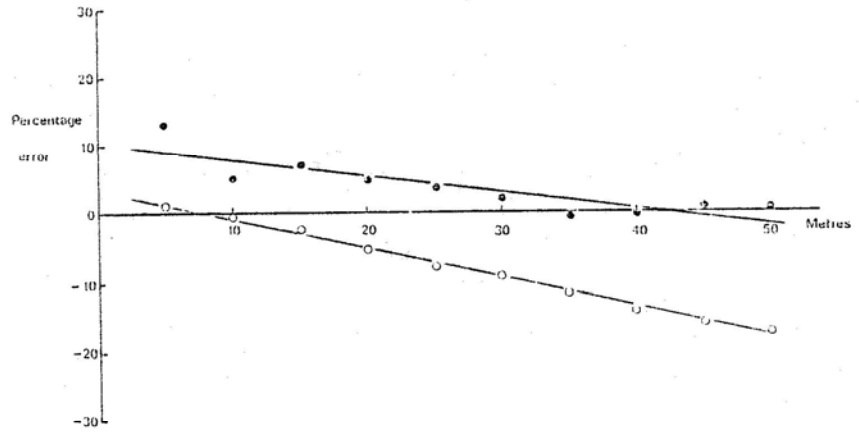


Figure 5. The relationship between the percentage error of each technique and the actual root length. ● , root length machine; ○ , grid method.

TABLE 1

Standard deviations, coefficients of variation and time taken for the grid method and the root machine with increasing root length. For each root length there were three estimates.

Actual Root length (m)	Grid Method			Root Machine		
	SD	CV	T	SD	CV	T
5	0.04	0.08	5	0.06	1.02	3 *
10	0.06	0.64	9.5	0.15	1.45	
15	0.17	1.15	13	0.10	0.62	
20	0.24	1.28	17	0.15	0.73	
25	0.12	0.51	21	0.40	1.54	
30	0.16	0.57	25.5	0.51	1.67	
35	0.12	0.39	29	0.21	0.60	
40	0.30	0.87	31	0.29	0.72	
45	0.21	0.56	34	0.58	1.27	
50	0.65	1.58	37	0.56	1.11	

SD = standard deviation (m)

CV = coefficient of variation (%)

T = time taken (minutes)

* time taken for root machine was 3 minutes for all samples.

calibration curve was linear over the entire range whereas the grid calibration was curvilinear. Each Line had a very high correlation coefficient indicating a close relationship between the direct measurement and the estimates. Over the range of root length tested, the machine overestimated while the grid underestimated. This **was** probably due, in part, to the small particles of organic matter, such as bark, which readily sloughed off the sample. In an automatic method all contaminants are counted along with the roots whereas in the grid method they are easily distinguished and avoided. Figure 3 shows the percentage error of each technique over the range of lengths considered. Taking figure 4 and figure 5 together it appeared that the machine gave the best estimate (+ 5 per cent of the actual length) for the longer samples (20-50 m) and the grid method the best estimate for shorter samples (5-20 m). The Linear fall off in this percentage error is both cases was probably due to the increasing incidence of overlapping as the sample length increased. The fall off **was** faster in the visual method suggesting that operator fatigue and loss of resolution vas involved.

In contrast to the machine which has a standard scanning time (3 min) the time taken to finish counting a sample using the visual method increased Linearly as sample size increased (table I).

Beginning with cut root pieces the time **to** prepare and arrange a sample in either method was always less than 3 minutes.

Table I also shows standard deviations and coefficients of variation (standard deviation/mean s 100) of the length estimates. 3och methods had very Low coefficients indicating a high level of precision. A 3 per cent coefficient of variation has been considered acceptable (Tennant 1973). The coefficients of variation for both the grid method and the machine were Lower than those reported by Newman (1966), Reicosky ec al. (1970) and Rowse and Phillips **(1974)** but comparable with chose of :annant (1973). In both methods the standard deviation tended to increase with increasing root length.

This probably reflects the tendency for roots to clump together as the sample size increase. In neither method does there appear to be a trend in the coefficients of variation.

The methods reported here were tasted using replicate samples enabling statistical details of accuracy and variability to be assessed. In the normal use of the machine it is considered that a single estimate of a sample with reference to the table of statistics would be sufficient.

Acknowledgements

The authors are indebted to W. N. Garwoli and M. W. Daly of the Royal eelbourne Institute of Technology for the design and construction of the root machine.

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XI. A NOTE ON ENPRESSING PHOTOSYNTHESIS EFFICIENCY

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In certain agricultural textbooks but more especially popular articles on world food production potentials, one finds very confusing statements of and expressions For the efficiency of photosynthesis. The following summary *is* presented in order to outline in this context the basic problems related to the expression of this efficiency. More references jave been given elsewhere (Stigter, 1978).

From the chemistry of the reaction it can be shown that a 100% efficiency of the basic photosynthetic process should correspond to an energy fixation, without losses, of about two Einstein active quanta of solar radiation for the reduction of one mole of CO2(e. G. Wassink 1968). From the actual energy distribution in the photochemical apparatus of photosynthesis, the quantum requirement appears to be a minimum of eight to ten quanta, from which would follow a maximum basic efficiency of about 20% to 25% of total absorbed active quanta.

If one wants to **express** this basic efficiency as a percentage of total incoming solar radiation (T I S) one has to consider the

a) amount of solar radiation that is potentially active in photosynthesis processes (PAS)
b) reflection of PAS
c) inactive absorption of PAS
d) actual quantum yield.

However, the figures of maximum basic efficiency given above are not of much use in this context, as they apply when light is the only limiting factor. Under field conditions CO_2 will be a limiting factor as well and an appropriate statement should at least read:

"Maximum gro2s photosynthetic efficiency of a C_3- plant type leaf (for example), absorbing x ı J/m s (or x2 Einstein/m^2s) active solar radiation (or quanta), is of the order of y% of that amount under bulk air CO2- concentrations of z v.p.m. outside its boundary layer".

Of course, x1, x2, and y do now contain assumptions or measurements regarding points a) to d) above, that should preferable be explicitly stated together with conditions determining CO2 diffusion into and within the leaf.

Even with this improved statement, together with the explicit assumptions, one problem remains. The use of a well defined active solar radiation is complicated by the existence of spectral differences in the action efficiency of PAS and , including absorption, of spectral differences in quantum yield. For example McCree (1972) found for a typical plant from the many species he tested that neither the mean action spectrum nor the mean quantum yield are constant throughout the PAS wavelength region of the solar radiation spectrum. Therefore neither absorbed PAS (or TIS) nor the flux of absorbed quanta are as such perfect measures for absorbed active radiation, although the latter appears to be more accurate (McCrea, 1972).

Given this situation it should be a prerequisite that any statement on (maximum) efficiency of gross photosynthesis also indicates the assumption on these spectral differences together with the other assumptions outlined above. The same applies to statements on (maximum) net photosynthesis, taking assumptions on respiration losses into account. On a crop basis assumptions on crop radiation distribution should be added.

From the above one would expect that the most meaningful real (maximum) net photosynthesis efficiencies out of doors on a crop basis would be those expressed as measured (maximum) dry matter production as a function of measured TIS (or equivalently of measured PAS, if this is indeed a rather conservative percentage of measured TIS)(Williams 1976). However, problems related to crop sampling procedures, marginal effects in small plots and other experimental inaccuracies have recently been shown to lead also easily to wrong conclusions (Monteith 1978). Crop photosynthesis modelling, using assumptions on leaf parts photosynthesis efficiency apparently still has some tasks shead.

Aknowledgements

I am most thank to Dr. J. A. Kapuya of the Botany Department of this University, for a discussion on a draft of this note. Dr. Brian Williams, of my Department, was again so kind to polish the English.

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XII. DEVELOPMENT OF PRACTICAL TECHNIQUES FOR ENVIRONMENT CONTROL FOR HORTICULTURAL CROPS

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SUMMARY

A practical design of a polyfilm duct system for application to greenhouses is outlined in detail. This calculates fan operating pressures consistently at about 10% above actual measurements.

1. INTRODUCTION

The development of the polyfilm Duct System has already been described in another paper (Sproules and Thom, 1978).

2. NOTATION

P = air pressure with various subscripts - Pascals (Pa)

P = pressure due to velocity - Pa (IHVE Guide, 1970)

K = constants with various subscripts relating pressure to velocity pressure Pv

Q1 = outlet volume - 1. s.-1

V1 = outlet velocity (theoretical average) - m. S.

A = area of outlet m-

T = Throw - m

3. DESIGN METHOD

Solar radiation provides most of the heat input to a greenhouse which is about 70% of the radiation incident on a glass roof (Garzoli, 1971). For economic reasons some form of shading is essential to reduce this solar input to half.

Conducted heat input is calculated for a desired internal temperature of 30°C. This temperature is obtainable with evaporative cooling (efficiency - 0.8) for all but about 20 to 25 hours per annum (Cunliffe and Kowalczewski, 1967).

Following Garzoli's method (1971) a heat balance equation is set up from which the air flow is calculated to provide the desired internal dry bulb temperature.

Propeller fans are selected to operate at 60 Pa based on size to suit the house. Commercially available evaporative coolers using centrifugal fans can be a Lower cost alternative.

3.1. Duct Selection

The duct size initially is chosen to be 1.5 times the propeller fan diameter, or a cross-sectional area of 2.25 times the outlet area of a cooler.

The throw of the multiple outlets *is-*

$$T = \frac{\text{House or bay width} - \text{duct no.} \times \text{duct dia.}}{2 \times \text{duct no.}} \quad (1)$$

Then two equations (Sproules and Thom,1978) are calculated to determine outlet number, diameter and spacing

$Q_i = 5.0\ T^2$ (2) and $D = 27\ T$ (3)

3.2 Summar Pressure Calculations

There are three pressures caused by the duct. (Osborne and Turner,1967)

3.2.1. Pressure across outlet - Po

Measurements have indicated that for simple outlets the constant $K_o = 0.3$ in -

$Po = Ko \times P\ v$ (outlets) (^{4})

'Where V_I is set equal to 9 m. $S.^{-1}$

then = 48 Pa, and Po = 24 Pa

3.2.2. Pressure at transition - P_t

To enter an outlet the air in the duct turns at right angles causing a pressure loss related to initial duct velocity by the equation -

$$P_t = K_t \times Pv_{(duct)} \quad (5)$$

Where K_t is a constant determined by the ratio of outlet diameter to duct diameter (Osborne and Turaer 1967).

3.2.3. Pressure due friction - Pf

Friction pressure in the multiple outlet duct is determined from –

Pf = Pf(unit length) x (0.5 x duct length) x outlet coeff (6)

Where friction pressure Loss per unit length is from tables for round galvanized steel ducting (IHNE Guide, 1970) and coefficient for outlet number from Table I. (Christiansen/1942).

3.2.4. Total Duct Pressure

Therefore the total duct pressure (Pd) at the fan is-

$$P_d = P_o + P_t + P_f - Pf \quad (7)$$

and at the end remote from the fan (P_e) is -

$$P_e = P_o + P_t + P_f \quad (8)$$

If the pressure gradient along the duct varies b9 20% the outlet volume varies by 10% (Woodward,1959). Therefore -

$$\text{Pressure gradient} - \frac{Pf \times 100}{Po + Pt + Pf} \quad \% \text{ is not greater than } 20\% \qquad (9)$$

Table I

FACTORS FOR MULTIPLE OUTLETS

NO OF OUTLETS	FACTOR	NO OF OUTLETS	FACTOR
1	1.0	16	0.382
2	0.639	17	0.380
3	0.535	18	0.379
4	0.486	19	0.377
5	0.457	20	0.376
6	0.435	22	0.374
7	0.425	24	0.372
8	0.415	26	0.370
9	0.409	28	0.369
10	0.402	30	0.368
11	0.397	35	0.365
12	0.394	40	0.364
13	0.391	50	0.361
14	0.387	100	0.356
15	0.384	>100	0.351

3.2.5 Fan Operating Pressure

The loss of pressure through evaporative cooler pads is about 25 Pa because these are sized for an average velocity through the pad surface of 1.25 m. S.⁻I. This *is* added to P_o P_t to determine the fan operating pressure.•

3.3. Calculation for Winter Operation

The volume of air per outlet in winter is -

$$Q_1 = 0.10\ TD \qquad (10)$$

This ensures that one fan is capable of providing the winter air flow.

The winter pressure is calculated as follows.

3.3.1. Pressure across outlet – Po

V1 = Q1 / A (11) and Po = Ko x Pv (outlet)

3.3.2. Pressure at transition - P_t

With one fan operating the velocity of air entering the duct is the same as the summer condition. Therefore P_t remains the same.

WALL OF BUILDING POLTTSIGNE DAIAPEA TREE 4 3 - CAMPER SOS NALL OF BULGING

3.3.3 Pressure due to friction - P_f

The unit friction loss is the same as for summer but along the full duct length and the outlet number has doubled, where -

$$P_f = P_f \text{ (unit length)} \times \text{duct length} \times \text{new coeff} \qquad (13)$$

3.3.4 Total Duct Pressure

The total duct pressure is calculated as in (7) and (8) but as the outlet pressure has fallen and friction pressure risen then

Pressure Gradient = $P_f \times 100 / (P_o + P_t + P_f)$ % is not greater than 40%

This tolerance has been increased becauie most of the air is recirculated. More air arrives at the end remote from the fan, reducing short-circuiting from outlets close to the fan. This is the most critical constraint for duct sizing.

3.3.3 Total Fan Pressure

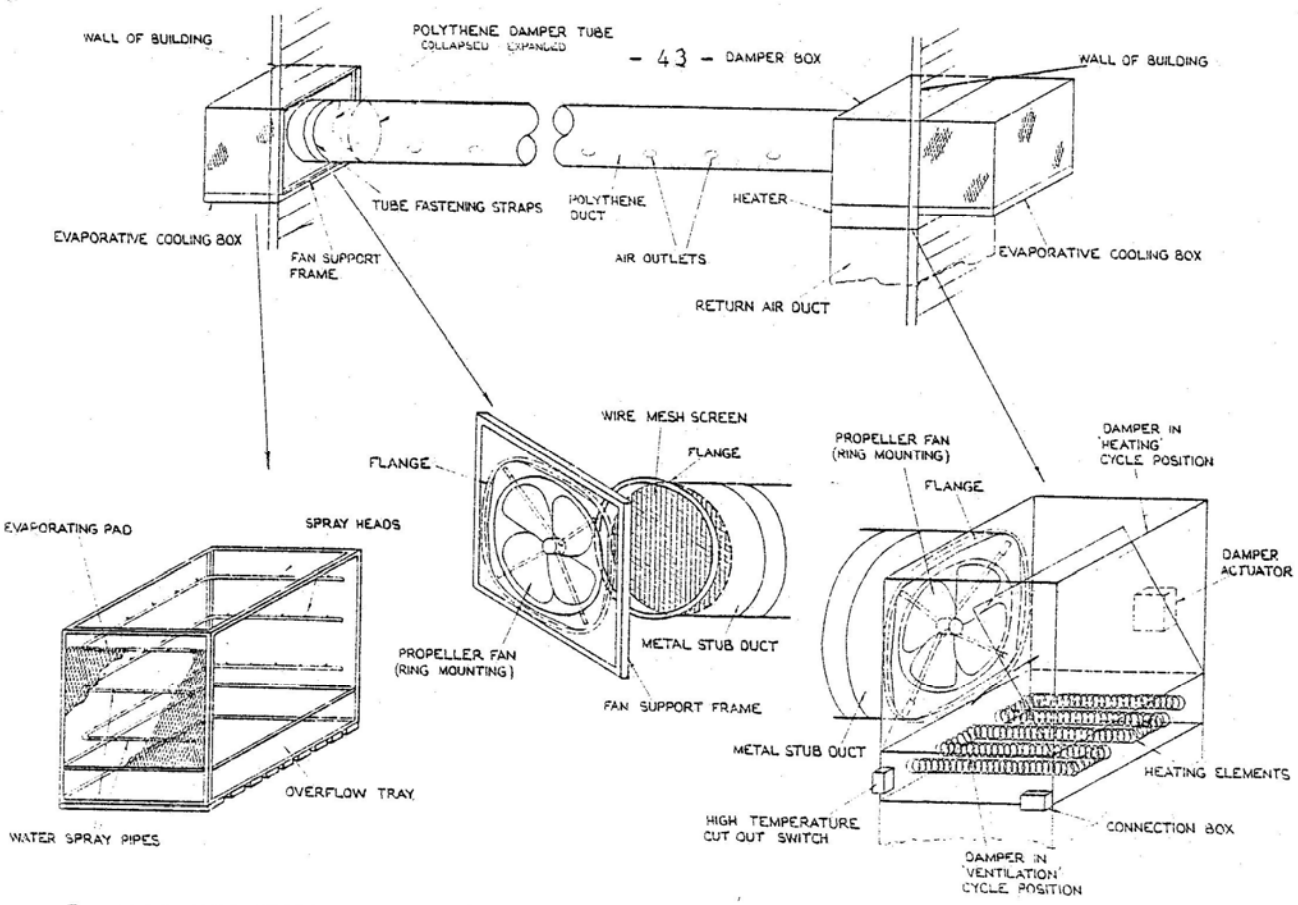
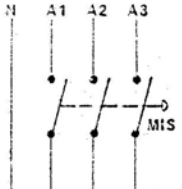
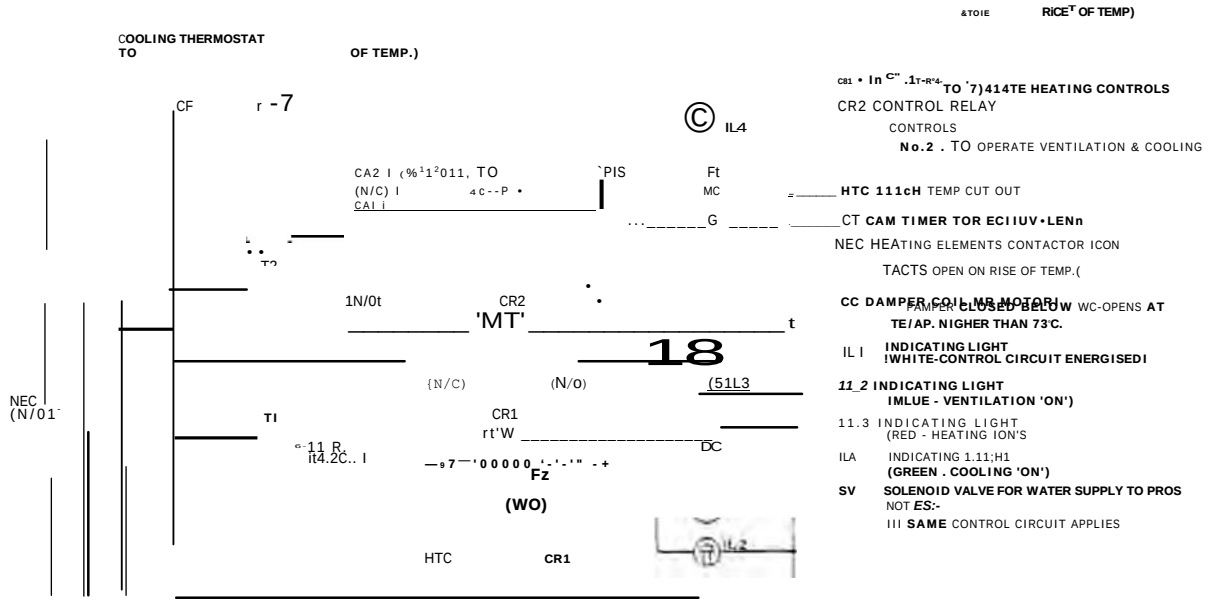


FIG. 1 RECOMMENDED DUCTED HEATING, VENTILATION AND COOLING INSTALLATION



LEGEND

MIS	MAIN ISOLATING SWITCH
LF	LOAD FUSES
CF	CONTROL FUSE
F1	FAN (AT HEATER END)
F2	FAN
IS	ISOLATING SWITCHES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HTC 111cH TEMP CUT OUT
CT CAM TIMER TOR ECIIUV•LENn
NEC HEATING ELEMENTS CONTACTOR ICON
TACTS OPEN ON RISE OF TEMP.(
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CR2
'MT'
t
18
{N/C)
(N/O)
(51L3
NEC
(N/01
TI
CR1
rt'W
DC
11 R
Fz
(WO)
HTC
CR1
TO '7)414TE HEATING CONTROLS
CR2 CONTROL RELAY
CONTROLS
No.2 . TO OPERATE VENTILATION & COOLING
FAMPER CLOSED BELOW WC-OPENS AT
TE/AP. NIGHER THAN 73'C.
IL I INDICATING LIGHT
!WHITE-CONTROL CIRCUIT ENERGISEDI
11_2 INDICATING LIGHT
IMLUE - VENTILATION 'ON')
11.3 INDICATING LIGHT
(RED - HEATING ION'S
ILA INDICATING 1.11;H1
(GREEN . COOLING 'ON')
SV SOLENOID VALVE FOR WATER SUPPLY TO PROS
NOT ES:-
III SAME CONTROL CIRCUIT APPLIES

CR2

4 CONCLUSIONS

The method outlined computes the complete design of the polyfilm duct system. In tests on new installations this method has consistently calculated fan operating pressures at 107. more than actual *measurements.*

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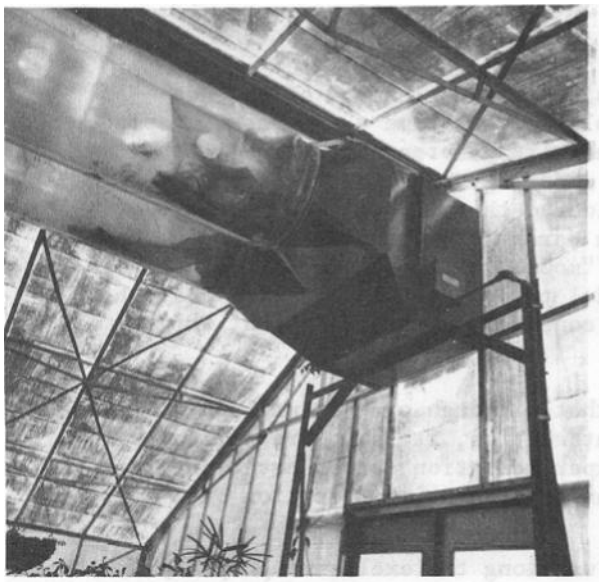
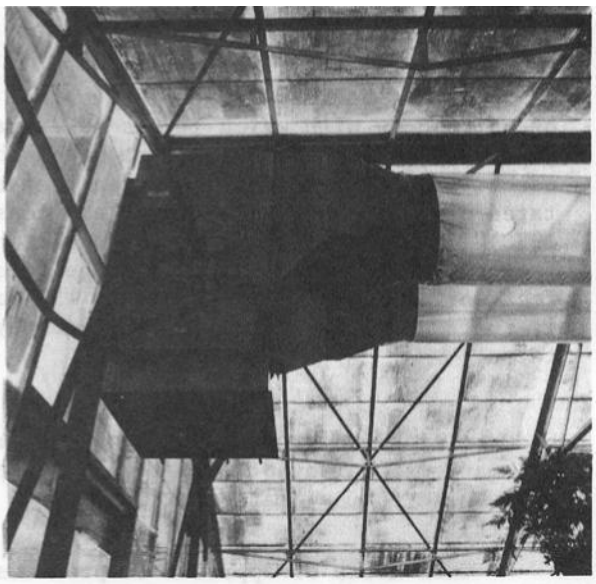
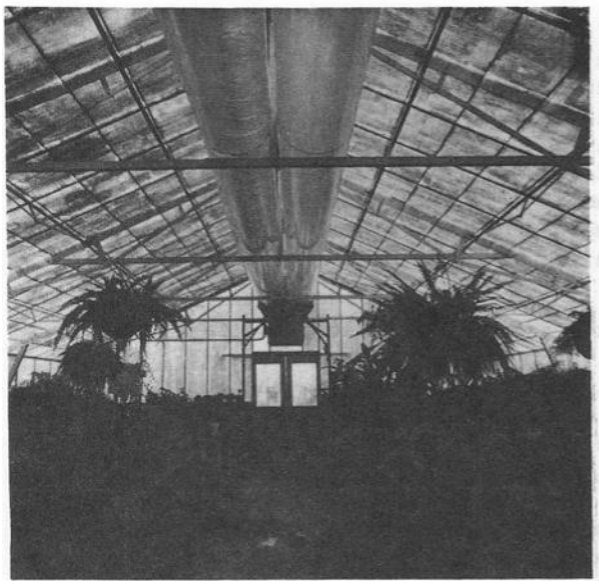
Explanation of yhotographs (page 43)

1. polyfilm Duct Installed Underneath Benches
2. Summer Ventilation Section with Collapsible Polyfiim Damper Visible
3. Gable Mounted, Twin Polyfilm Duct Installation
4. Winter Heating and Recirculation Section.







[XIII. MODELS IN PLANT PHYSIOLOGY AN EXAMPLE IN PHOTOPERIODTS711

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It has become trite to state that since the beginnings of science - or of philosophy with which it was inseparable at that time - man has been preoccupied with models. The ancient Greeks had already proposed models of the Universe. It should not be forgotten that a model may be either that which is imitated or that which imitates. Plato considered that (if we refer to SORDET, 1970)"... all that which is found here on earth is nothing more than an imperfect reflection or a degraded image of a "model" which exists in another perfect world". Thus, Plato believed the model to be the thing itself, that which is imitated. The model we will presently consider, however, is that which imitates.

Within this context, we may state that although experimental physics dates back to Archimedes and even to earlier mathematics, it is modern science with its mathematical hypothesis coupled to experimentation (or observation) that has given rise to the "mathematical model", an abstract simplification of a complex reality.

This means of approach to problems was long the exclusive property of physics which, if need be, created the mathematics required for its development and so naturally constructed models without expressly stating so. The current importance of the word appears to be related first to the common application of mathematics to economics (econometric models), then to the domains of biology and the environment which, unlike economics but similar to physics, are fields of practical experimentation, and, finally, to practically all fields of science, including the social sciences.

A result of this spread is an abuse of language, so that a "model" has become a simple fitting of conventional curves to experimental of observationnal data. When in 1845 VERHULST formulated "logistics" from the differential dv/dt= cv (a-v) to explain population growth, he "constructed a model". The same can be said of ROBERTSON, who much later (1923), formulated, on the basis of the same differential dw/dt = kw (a-w), the hypothesis of the "autocatalytic monomolecular reaction" of LOEB (1906) to explain the weight or size growth of a living organism or of one of its organs. But that which merely adjusts logistics to the data is not a model.

We should consider that there are two conceptual categories of mathematical models, "empirical" models and those which are termed "mechanistic" or "theoretical" not only in opposition to empirical, but also because the construction of a true model is the construction of a theory. A hypothesis which is confirmed, or rather which is not invalidated by the facts, may become a theory.

At the basis of mechanistic models there is indeed invariably an "axiomatic", which is generally inspired by experimental or observational facts. It is a set of hypotheses - which may not be novel, except for their association - and/or of well established principles (the principles of conservation of mass and energy, of least action...) which refers to the nature of the constituents of the "system" to be modeled as well as to their behavior and their interactions. Hypotheses and principles generally refer to prior state of science, considered as acquired, which contributes to an acceptance of the conclusions, providing they are not falsified by the facts.

The notions of a model and of a system are intimately related. A model is indeed one representation of a system (there may be many). This system may itself be a sub-system of a more complex system which in turn is composed of sub-systems. In other words, a model is simply and abstract image of the product of a reasoned and reasonable punching of reality. The model itself constitues a more or less complex system.

Hypotheses and principles are indeed translated into a system of equations which constitues the model. That which remains, and which is not always the least difficult task, is to find solutions to the equations and to compare the numerical results to the existing data.

It is not alwayspossible (or useful) to construct a theoretical model, at least a priori. The process then becomes empirical, beginning with a detailed knowledge of the data, knowledge eventually acquired by novel methods of data analysis, followed by the intuitive search (with some trial and error) of a system of conventional equations whose solutions will satisfactorily account for the experimental results.

There is in fact no borderline between a theoretical and an empirical model A model may be partially empirical and partially theoretical. It may be theoretical at the beginning, becoming empiricial, or vice-versa. During the elaboration of the model, we also *pass* through alternative phases of theory and empiricism. Passing from theory to facts and from facts to theory is a constant procedure in scientific dialectics.

An example of a complex procedure involves models of the phenomenon of photoperiodism, whose starting point was the first true model conceived in plant biology. It is not an accident that this model *was* formulated by a physicist, REAUMUR. In 1735, the inventor of the thermometer, lenting a mathematical support to a physical principle, formulated the hypothesis that the complete development of a plant, from beginning to end, could always require "the same sum of temperatures" accumulated daily.,

For those who negate any physical and/or physiological significance to summing temperatures, we may say immediatly that the quantities of$_r$ heat (thus of energy) Q_i absorbed by the plant during the *n* successive days of its development is expressed as Q, a cT_i , where c is the heat conductibility coefficient of the plant (presumed to be constant) and T_i is the mean temperature of the ith day. This hypothesis is writtent as follows:

$$\sum_{i=1}^{n} T_i = K \qquad K = \text{constant}$$

All the conditions of a theoretical model are found in this extremely simple formulation. All that remains is its validation, which has been attempted by generations of biologists and meteorologists, who found that the proposition would be improved, i.e. would become less approximative and could be extended to a larger number of plants, if we added a second hypothesis to the axiomatic: the vegetation zero of a given plant is a specific characteristic which is distinct from the thermometric zero. Given T_o, this biological zero below which vegetative process are totally inhibited, the axiomatic is now written:

$$\sum_{i=1}^{n} (T_i - T_o) = K \qquad (1)$$

There are numerous exceptions to this rule, but the fact that the model has not been rejected is undoubtedly related to the fact that it explains a certain number of cases and also has been proven useful for some time for programming plantings and thus harvests of plant to be canned. Another fact was the prescience of certain workers that lighting conditions could play a role, confirmed by TOURNOIS (1912) and then by GARNER and ALLARD (1920) , who confered

on "photoperiodism" its special characteristic of not being related to the intensity of the light, but rather to its duration (day length).

Twenty additionnal years were required before GESLIN (1944) and NUTTON SON (1948) empirically introduced into the model the expression of this day length, or photoperiod (noted here as H):

$$\sum \left[(T_i - T_o) H_i \right] = K \qquad (2)$$

or

$$\left[\sum (T_i - T_o) \right] \overline{H}_i = K \qquad (3)$$

with H. the length of the ith day and avg Hi. the mean day length between germination and flliwering, defined by a criterion such as initiation, earing, anthesis etc..

During the following thirty years, numerous attempts at the interpretation and/or the application of these formulas resulted only to rearrangements which questionned the modality - occasionally the principle - of summing temperatures. Among ocher things, it was pointed out that not only did a minimal T. have to be taken into accound (zero of vegetation) but also a maximal T., beyond which temperatures would no longer be favourable; it was also indicated that in order for the summing of temperatures to have a real physiological significance, it had no be performed not daily, but hourly; since the rate of development was an exponential function of temperature, a linear summation of temperatures would only be an approximation, it is not quantities of energy that are summed with the temperatures of successive days, but rather elementary developments which are proportionnal to these temperatures . Based on the latter two arguments it was even proposed to substitute a sum of $_{Q10}$ for the sum of temperatures.

In spite of their importance, these considerations of the means of expressing temperature are not fundamental, at least from the point of view of where the theory was at that time. It was deemed more useful to uncover the features distinguishing formulas (2) and (3), which are not identical mathematically, for physiological distinction. More important, it was noted that they are only valid (eventually) for long day plants and not for short day plants, an observation which had apparently never been made. Although a partial theory is provisonnally never devoid of importance - a fact well illustrated by the present historical summary - an exclusive condition for the validity of a theory, which necessarily tends to become unitary, is that it may be generalized to all cases.

In the present context, not only to short day plants, but to photoperiodically neutral plants as well.

Starting from basic considerations, either empirical or theoretical and often intuitive, it is possible to go from expression (3) to a series of models which are progressively more representative of the apparent (non molecular) phenomena of photoperiodism (FRANQUIN, 1974, 1976):

A formulation no longer including only one (K), but two parameters of the rectangular hyperbole (or homographic) function (of which there are 3):

Long day plants $$\sum (T_i - T_o) = \frac{K}{\overline{H}_i - H_o} \quad (4)$$

Short day plants $$\sum (T_i - T_o) = \frac{K}{H_o - \overline{H}_i} \quad (5)$$

At least two parameters are obviously necessary to distinguish long day from short day plants; the second parameter, H_o, is nothing more than the critical photoperiod. The inversion of sign in the denominators of (4) and (5) expresses that a long day plant will flower for photoperiods $\overline{H}_i$ greater than the critical photoperiod H_o and that a short day plant will flower when $\overline{H}_i$ is less than H_o.

A formulation involving three parameters of the homographic function:

Long day plants $$\sum (T_i - T_o) = k_o + \frac{k}{\overline{H}_i - H_o} \quad (6)$$

Short day plants $$\sum (T_i - T_o) = k_o + \frac{k}{H_o - \overline{H}_i} \quad (7)$$

The best possible statistical fit of the function to the experimental data (FRANQUIN, 1974, 1976) will obviously be obtained with the introduction of the third parameter , k_o, which is interpreted as representing the length of the juvenile phase.

—A formulation enabling the theory to be extended to neutral plants:

Long day plants $$\sum (T_i - T_o) = k_o + \frac{k}{1 - \frac{H_o}{\overline{H}_i}} \quad (8)$$

Short day plants $$\sum (T_i - T_o) = k_o + \frac{k}{\frac{H_o}{\overline{H}_i} - 1} \quad (9)$$

A neutral plant has a critical photoperiod H_o obligatory nil and by definition no longer reacts to the length of the photoperiod. If, however, we set $H_o = 0$ in (6) , we have:

$$\sum (T_i - T_o) = k_o + k/\overline{H}_i$$

according to which the sum of the temperatures, which measures the time between termination and flowering and which should be independent of H, still varies with H.. On the other hand, if we set H. = 0 in (8) , we obtain :

$$\text{sum of } (T_i - T_o) = k_o + k = K$$

in which the sum of temperatures at flowering is independent of H and is equal to the sum of the two parameters, k., the length of the juvenile phase, and k, the time required by the neutral plant (which depends only on temperature) to flower once the juvenile phase is passed. **If** we now set this sum equal to a constant (K), the original relationship of REAUMUR is found (relationship (1) with a difference of T.).

-. A formulation enabling us to pass from the domain of the variation of the photoperiod H between 0 and 24 hours, to the interior of one 24 hour cycle, to the same variation in a succession of cycles, 24 hours thus taking on infinite dimensions, obtained by a "homography' transforming H to H/(24-H):

Long day plants
$$\sum (T_i - T_o) = k_o + \frac{k\left(1-\frac{H_o}{24}\right)}{1-\frac{H_o}{H_i}} \qquad (10)$$

Short day plants
$$\sum (T_i - T_o = k_o + \frac{k\left(1-\frac{H_o}{24}\right)}{\frac{H_o}{H_i} - 1} \qquad (11)$$

and as 24-H = N (duration of night) this models can be write:

Long day plants
$$\sum (T_i - T_o) = k_o + \frac{k}{1-\frac{H_o/N_o}{H_i/N_i}} \qquad (12)$$

Short day plants
$$\sum (T_i - T_o) = k_o + \frac{k}{\frac{H_o/N_o}{H_i/N_i} - 1} \qquad (13)$$

This is another way of stating that all plants can be characterized by a complementary critical hemeroperiod H. and nyctiperiod No : Ho + No = 24.

— A formulation which confers on system (12) + (13) a mathematical and physical coherence which. it lacks. Indeed, since the sum of temperatures (Ti - To) has the significance of time (time up to flowering), the denoMinator hlow k then has the dimension of velocity : if we consider (12), it is a relative velocity varying from 0 (for avg Hi = Ho) to 1 (for avg Hi = 24 and thus

0). This same reasoning *is* not valid for (13), however, where the denominator mays be greater than 1: this denominator will thus have the same significance of relative velocity for long and short day plants only in system (12) + (14), where *N* is substituted for H and inversely:

$$\text{Short day plants}\quad \text{sum of } (T_i - To) = ko + k \,/\, (1 - (No/Ho)/(Ni/Hi)) \qquad (14)$$

In this coherent system (12) + (13), long and short day plants, more appropriately termed hemeroperiodic and nyctiperiodic, are thus distinguished by the inverted relationship of N and H. For both types of plants, comparison of experimental data with models (12) and (14) is entirely satisfying (FRANQUIN, 1976).

Arriving at this point, we may attempt to arrive at this result beginning with an axiomatic.

The governing idea of this axiomatic is that the fundamental problem subjacent to the photoperiodic phenomenon is that of "time", i. E. that of the nature and the measurement of time. It is at this point that we enter the domain *of* physics which deals with the notion and the evaluation of time, echanics.

Partisans of the theory of rhythms in photoperiodism see the plant as an oscillator. This plant-oscillator which is characterized by an intrinsic period (the critical photoperiod), as are all oscillators, should thus have the same abstract image as that of a mechanical oscillator, which in its simplest form is the well known differential:

$$ma + ku = 0$$

Besides, supporters of the phytochrome theory are apparently faced with the difficulty of understanding how changes in state of this pigment enable the plants to measure this signal, which is the length of the nocturnal phase.

Thus, be it for an oscillator and/or phytochrome, the essential element of the problem remains time.

This concept of time should be defined whenever we propose the construction of a model, i. E. a theory.

It is not possible to correctly evaluate the response time to the photoperiod - for which the photoperiodic reaction is generally taken as a measure- if we neglect the effects of temperature and light intensity.

It is known that the number of 24 hour cycles required to determine floral induction depends on temperature. Indeed, it is the sum of daily temperatures, $(T_i - To)$, which is measure of response time. This *is* an endogenous biological time, nothing more than the astronomical time (or clock time) weighted by temperature. We may write approximately:

$$\text{Sum of } (T_i - T_o) = t\ (T_i - T.)$$

where t is the astronomical time in number of days and T_i is the mean temperature of this number of days.

This sum of temperatures also has a morphogenetic significance, since an identical sum of temperatures separates the emission of two successive leaves. The number of internodes or of plastochrones and *the* equivalent sum of temperatures thus have the same morphogenetic and physiological significances.

This endogenous time known only by the plant (which presumably is not familiar with our timepieces) is - as a first approximation - an absolute time, since astronomical time is only relative (to temperature) for the plant. Events occur as if this relative time dilated or contracted with temperature. This may be called the "plastochrone/temperature effect", which cannot be neglected when the response time is evaluated.

More generally, the photoperiodic phenomenon cannot be understood if it is not interpreted in relation to the number of internodes or plastochrones- this is just being recognized by some physiologists - and to the equivalent sum of temperatures. But we may also keep in mind that this sum of temperatures has a meaning only for a plant which is photosynthetically saturated with light, which generally occurs under natural conditions but is far from always being under controlled conditions. The non saturation of the plant by Light results in a "plastochrone/light effect" which is probably identical to the "photosynthesis effect" demonstrated in photoperiodism by certain physiologists. This affect mays totally falsify the conclusions based on response time as a measure of the photoperiodic reaction.

Given these precisions, concerning time as it is perceived in our axiomatic, we will enter the plant oscillator (among other elements which will be described subsequently) into tais axiomatic. The physical theory of oscillators has the advantage of being well known in its multiple forms: it thus has the interest of being useful for a variety of hypotheses concerning the modes of participation of the length of illumination and of temperature. Restricting ourselves to only linear oscillators, we may formulate at least four abstract images;

- a non damped oscillator	$mu + ku = 0$	(a)
- a non damped oscillator externally excited	$mu + ku = F.\sin wt$	(b)
- a damped oscillator (by friction)	$mu + hu * ku = 0$	(c)
- a damped oscillator externally excited	$mu + hu + ku = F. \sin wt$	(d)

In these expressions, u is the state of the system at time t, F is a function of external excitation and is an angular velocity.

If, in relation to the alternation of days and nights, a plant behaves as a linear oscillator which is also excited as a function of temperature, the integration of one of these four differentials - which will be subsequently explicited - must Lead to a mathematical model presenting certain qualities of the photoperiodic phenomenon. This is indeed what we find.

We will show in a future study that the integration of differential (d), where hu represents the friction effect related to the day-night alternation and F an excitation related to temperature, leads to a model very close to the system (12) + (14). According to the axiom of the oscillator , Z (T_i – Ti,) indeed represents a time, k a space rum through and the denominator under k a velocity (relative).

The physiological significance of ka, as already seen, is that it is the length of the juvenile phase, at the end of which the plant will reach flo ral maturity and will be able to initiate the process at the relative velocity of I in the minimal time k/1 in the absence of friction (neutral or hemeroperiodic plant for iT. 24 or nyctiperiodic plant (in principle) for 7. = 24). This minimal time k/I k probably represents the equivalent of a plasiochrone.

In biology, the development of a theory obviously does not imply passage through mathematical models, although this process has certain advantages, "the mathematical Language being the natural language of rigorous reasoning, which must be employed each time possible, in other words each time the concepts are clear and well defined " (VOGEL, 1973). The effort undertaken to formalize the concept of photoperiodic plant will obligatory contribute to its clarification and to its satisfactory definition.

Finally, on the subject of mathematical models in plant physiology, an authoritative work exists: "Mathematical models in Plant Physiology", by J. H. M. THORNLEY, Academic Press, New York, London, San Francisco, L976.

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XIV CLIMATIC ENVIRONMENT CABINET TO STUDY FACTORS IN PLANT GROWTH

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For several decades, phytotronics concerned itself with reproducing optimum conditions for plant growth in a controlled thermic and hygrometric environment, where artificial light was, more or less, successfully introduced.

Physiologists were never able to reproduce the *same* growth in closed systems as found in the field , and phytotronics only was able to contribute on method for resolving large scale problems.

It became necessary to rethink entirely the concept of the air conditioned growth cabinet and to produce improvements which would recreate a natural environment while at the same time maintaining its flexibility for use and its adaptability to the conditions being studied.

This task was taken on by the Aurore Company which is engaged in continuing technological research to solve scientific problems.

AIR CONDITIONING

Air-conditioning- temperature, hygrometry, ventilation- has not undergone major modifications during the last ten years, except for research on air-conditioner compactness and the cooling production system, especially on the possibility of feeding the cooling coils by direct expansion with proportional control of the evaporation tempe-
rature. The desired aim is achieved when a cooling coil, which controls the dew point tempera ure of the lower atmosphere, can be controlled within one degree. Tangential ventilation yields a perfect homogeneity on the entire ventilation front which concerns all the cul-
ture samples.

MODULAR SYSTEM

The multiplicity of individual plants, the age at which they are studied and the number of samples make it impossible to determine an ideal enclosed space of fixed dimensions. The IxIxlmmodules, which can be piled up and *set* up next to each other allow for all possible variations, without underestimating the possible mobility of a system which can be easily taken apart or built in phases according to available financing!

AIR-TIGHTNESS

Gaseous and hydric metabolisms, microbiology, genetics and parasitology, among others, require and air tight atmosphere. The rate of leaks should be at the level of a p. P. M., considering the sensitivity of the means of investigation offered by modern
sensors. The air tight cabinet, allowing for manipulation with a glove box and making it possible to introduce or to remove items through a lock sleeve, is essential in modern research.

LIGHT

The last word will never be said concerning sources of artificial light. Nevertheless, high intensities and spectra useful for morphogenesis and photosynthesis are presently obtained by lamps doped with metallic iodides. However, high intensities can nowadays be obtained on a small area, neither the electrical supply infrastructure, nor the thermal envelope of luminous ceilings, raising major investment or implementation problems.

NEW TRENDS IN RESEARCH

A rigorously controlled climate with a good homogenity in modular and air tight cabintes lit by high intensity in the favorable spectra, - all these requirements, are met in a single apparatus manufactured for several years by the Aurore Company. The mastery of initial difficulties guarantees the quality of three new technologies added to existing cabinets. In the same spirit that prevailed in developing the initial cabinet, these systems are also modular and can be perfectly adapted to existing apparatus already in operation.

Three trends are followed:

- thermal regulation of the root support
- simulation of the black bottom of the sky
- temperature regulation of walls

THERMAL REGULATION OF THE ROOTS

In classic phytotronics one of the drawbacks is that the rhizosphere cannot have a independent temperature variation from the atmosphere. Natural phenomenae are very different. Regarding the mass heat of soil, the evolution of root temperature does not follow atmospheric variations and it became advisable to remedy this drawback of the protected culture system.

The principle retained is ventilation by air of roots supports at a predetermined temperature (Vermiculite or earth pots, nutritive solution box). An insulating surface, pierced only for plant stems to pass through, separates the atmosphere of the roots and the support of their aerial parts, where the foliage are. The air of this root atmosphere *is* saturated with water to avoid any untimely drying of the supports. The air treatment circuit is integrated in a module measuringlxixlmwhich can be perfectly adapted to the existing modular system. It possesses its own stand alone regulation and cold production group. It does not interfere with peripheral adaptations: nutritive solution supply and automatic watering. Taken together in the same enclosure as the cabinet, it does not interfere with gaseous or hydric balance. Air and water are divided between the supports and aerial parts, but the whole mass is constant. Dosages, input and output, keep their proper value in relation to the analysis (Aurore Patent).

SIMULATION OF THE BLACK BOTTOM OF THE SKY

No chamber knows the phenomenon of dew, so frequent in nature and the generator of a multitude of phenomenas (the microbiology of the epythelium). The radiation of plants towards the black body which constitutes a clear night sky is possible in phytotronics if the ceiling of the chamber is no longer white but black and maintained at a very low temperature (-60° appears to *be* a sufficient value).

The blotting out of the white day screen, the appearance of the black screen at -60°, the ventilation of the lamp during the day and the perfect light-tightness in the night (no frosting on the black screen), are done in an original manner and in such a way that the whole is automated with high reliability.

As for the thermic regulation of roots, the ceiling can be adapted on the 1x1x1 m Aurore module and there is no more overcrowding than that existing before (Aurore Patent).

REGULATION OF WALL TEMPERATURE

As for the black bottom of the sky, it has been frequently observed that the lateral plant radiation conferred a substantial Lowering of leaf temperature, above all when wind velocity is not a determinant in the "leaf temperature- ambient air temperature" balance.

Protected cultures under glass will greatly benefit from the implementation of energy saving technology such as the recuperation of calories from nuclear plants and the use of solar energy.

In a greenhouse, the effect of the wall on cultures is considerable and completely unforesceeable at this time, the contribution or loss of calories are still partially controllable and their effect on cultures practically unknown.

Aurore proposes a system which in adapted to the air-tight modular cabinet which consists of replacing isothermic walls by double *walls,* the inside of which can be regulated in temperature, with a positive or negative difference in respect to the ambient air (Aurore Patent).

CONCLUSION

From the simplest cabinet to one which encloses all accessories, a multitude of cabinets exist, that are built from standard elements. Whatever be the original choice, it is always possible to add or take away an element in order to meet as close as possible optimum operating conditions.

XV. THEORETICAL AND TECHNICAL ASPECTS OF CO_2 ENRICHMENT OF GREENHOUSE ATMOSPHERE IN TOMATO PRODUCTION

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Institute of Horticultural Production of Krakow Agricultural Academy and Institute of Plant Physiology of the Polish Academy of Sciences in Krakow. InAAN9

The dynamic development of horticulture stimulated by the growing food demand, is based on modern greenhouse facilities and production techniques. In the intensification of greenhouse production such factors as fertilization, watering, new varieties, and increased CO_2 concentrations were taken into consideration.

Kreusler 1885, Brown and Escombe 1902, Tereboux 1903, and Pantanelli 1904 were first to report on the possible increase in photosynthetic activity by CO_2, enrichment. Also it was found 80 years ago/Zelitch 1971/ that the productivity of plants could be enhanced by increased CO_2 concentrations.

In Poland, the *use* of CO_2 enrichment is still in the experimental stage, though, the investigations suggest serious increases in the productivity and yield of plants grown in enriched atmosphere. The basic difficulty *is* the lack of low cost sources of CO_2.

In the years 1975-1978 the Institute of Horticultural Production of the Agricultural Academy in Krakow and the Institute of Plant Physiology of the Polish Academy of Sciences in Krakow carried out theoretical investigation with practical application on the determination of optimal conditions of CO_2 enrichment in greenhouse tomato production. In the present paper three basic elements were considered:

1. A theoretical study on the influence of increased CO_2 concentration on photosynthetic rate,
2. technical problems of CO_2 enrichment and of recording of climatic factors,
3. production effects of CO_2 enrichment in greenhouse tomato growing.

1. A theoretical study on the influence of increased CO_2 concentration on photosynthetic rate

In the photosynthetical process two groups of factors which are decisive for the final effect of net photosynthesis, are differentiated. The first group is related to the light stage of the photosynthesis, where the flow of electrons and protons in the chain of conversions leading to the formation of the energetistic factor in ATP and the rediction factor in NADPH the products indispensable for PGA reduction to the aldehyde level, is begun by the photochemical reaction in PS I and PS II. The second stage concerns enzymatic conversions in the Calvin-Benson cycle.

Both, the data from the literature (Gaastra 1959, Badger and Collatz 1977) and the present authors" own results from measurements carried out on tomato leaves (Revermun cv) (Fig.') show that considerable surpluses of energetistic and reduction factors of the photosynthetical process, yielded by light reactions, occur. In our opinion the occurence of these surpluses is supported by the possibility of increasing net photosynthesis rate by greater CO_2 concentration only, the Light energy being maintained at a constant level not only in the range of saturating intensity.

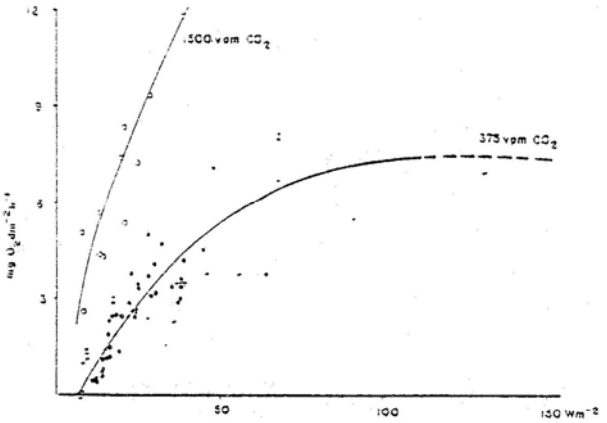

Fig.1. NET PHOTOSYNTHETIC INTENSITY /P_N/ OF TOMATOES /REVERMUN cv./ AS DEPENDING UPON LIGHT CONDITIONS AND CO_2 CONCENTRATION. MEASUREMENTS WERE TAKEN DIRECTLY ON PLANTS WITH THE OXYGOR UNDER GREENHOUSE CONDITIONS.

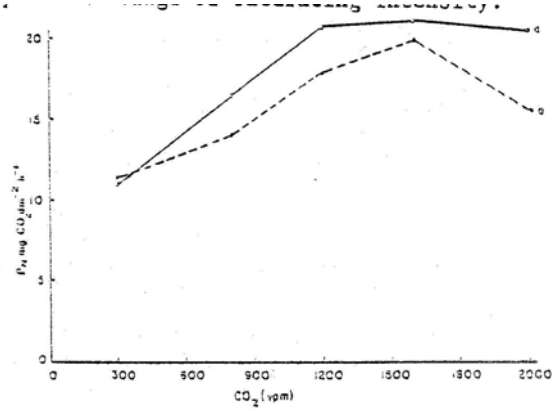

Fig.3. DEPENDENCE OF NET PHOTOSYNTHESIS /P_N/ ON CO_2 CONCENTRATION.
a - TOMATO TRANSPLANTS AT 4-5 WEEKS,
b - TOMATO TRANSPLANTS AT AGE TO 2 WEEKS.

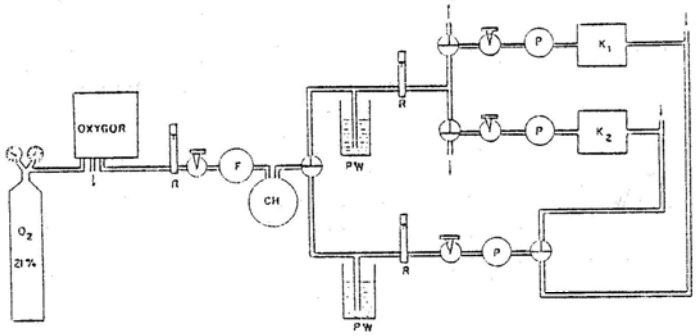

Fig.2. SCHEME OF THE GAS PASSAGE TO NET PHOTOSYNTHEIC MEASUREMENT OF GREENHOUSE TOMATO LEAVES WITH THE OXYGOR.
CH - ELECTRICAL COOLER ; K_1, K_2 - ASSIMILATION CHAMBERS ; F - AIR FILTER ; R - ROTAMETER , P - PUMP ; PW - WASHER.

The curves ie Fig.1 were plotted on the basis of net photosynthesis measurements, carried out directly in the greenhouse, in relation to the local light conditions, near a leaf level, for CO, concentrations of 375 and 1500 vpm (+ 75 vpm). Temporary fluctuations of CO_2 concentration in the greenhouse atmosphere reached 500 vpm owing to the pulsatory replenishment of decreases with pure 100-percent CO2 in 12 minute cycles. It is clear that these disproportions were increased at times when the greenhouse was aired.

Maihak (FRG) Oxygor, an apparatus based on paramagnetic properties of 0applied in the measurements, proved useful under these conditions since CO_2 differences, as well as these in FL„0 and U_2, were treated as a neutral measurement $_{2}$'
medium. The measurement range of the oxymeter comprised 1000 vpm 0_2 in a differential system in relation to the comparative air with a normal 0_2 concentration. The scheme of the measurement Leaves, is presented in Fig.2.

Returning to the measurement executed in the greenhouses (Fig.1) it should be stated that in our conditions the average photosynthetically active radiation (PhAR) intensity value in the greenhouse *was* on a level of 50 W. M - for most leaves. This is caused not only by the large number of cloudy days but also by the mutual shading of leaves.

From a comparison of the course of both curveson the graph, we can see that even below 50 W. M , at low intensities, maintaining CO, concentration at 1500 vpm increases the photosynthetic level by more than twetimes as compared with 375 vpm. These results from theoretical premises for compensating the lowered light intensity with increased CO_2 concentration. This statement partly weakens the view that the effects of CO, enrichment can be expected only in beneficial light conditions.

On the basis of Laboratory measurements of tomato leaves (Revermun cv), made with infrared gas analyser (IRGA) with a CO, feeding system (Starzecki 1979), is was found that a smaller decrease in potential photosynthesis (i. E. net photosynthesis determined at saturating light intensity and saturating CO_2 concentration las a result of ageing of leaves occurred in plants from CO_2 enriched chambers. While a month after growth had stopped leaves from the control chamber showed a decrease in net photosynthesis of about 30Z on the average, in the same period this decrease in the leaves from CO_2 enriched chambers *was* only 10%.

These data suggest that with the increased CO, cnncentration in the air, the photosynthetical apparatus is maintained longer and more efficiently. Moreover, it *is* possible that with leaf age enzymatic conversions of the Calvin-Benson cycle are inhibited more strongly and rapidly than the formation of energetistic and reductive factors in light reactions. At present, it is difficult to decide whether this is related to a stronger appareance of the oxygenase character of 1,5-diphosphate ribulose.

It is considered that besides saturation of this process, the closing of stomatal apparatus and increasing of R diffusion resistance (Gaastra, 1959, Pallas 1965, Zelitch 1971) may be important factors of photosynthesis inhibition at high CO_2 concentrations. In our experiments in the range of applied CO_9 concentrationga clear inhibition of net photosynthesis which can be attributed to the increased R resistance, was noted only in the case of young plants (2-week transplants) at^{s}2000 vpm of CO_2 (Fig.3). This would indicate a greeted sensitivity of stomatal apparatus of young plants.

2. Technical problems of CO_2 enrichment and of recording of climatic factors

Obtaining the expected growth in greehouse vegetable yields by increasing CO, concentrations in the air with the simultaneous control of basic climatic factors, required a design and construction of measurement and dosage apparatus.

Eight 40 sq. M. greenhouse chambers were designated for the realization of the experiments. In 2 chambers a normal CO_2 concentration (app. 300 vpm) *was* kept. In the remaining chambers it was raised as high as 2000 vpm, while opening the vent-hole distrubed the programmed CO_2 concentration (Fig.4) . As a CO_2 source pressurized tanks offering great freedom of CO_2 regulation and securing high CO_2 purity were used.

The control of climatic factors and regulation of CO_2 concentration was carried out with the help of thermal sensing device, hygrometers, PhAR gauges, and infra-red gaz analyser CIRCA), connected with the electronic recording and controlling system, made according to CAMAC standard (Fig.5).

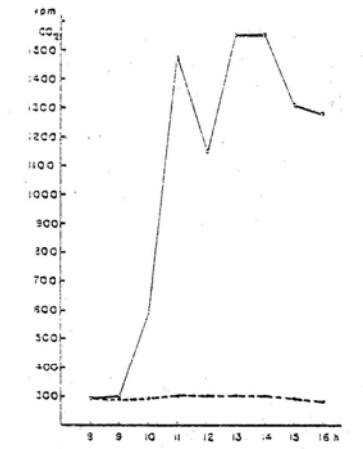

Fig. 4. THE AVERAGE VALUES OF CO_2 CONCENTRATION AT 1-HOUR INTERVALS

—— CO_2 CHAMBER TO 1500 vpm
--- CONTROL CHAMBER, app. 300 vpm.

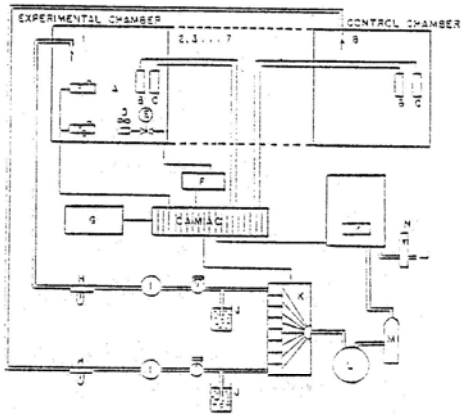

Fig.5. SCHEME OF THE CAMAC SYSTEM FOR MEASURING CLIMATIC FACTORS AND CO_2 DOSING IN 8 GREENHOUSE MEASUREMENT CHAMBERS.
A - PhAR MEASUREMENT SOUNDER; B - HUMIDITY GAUGE; C - TEMPERATURE SENSING DEVICE; D - VENTILATOR FOR CO_2 MIXING; E - CO_2 TANKS WITH VALVES; H - AIR FILTER; I - PUMP; J - WASHER; K - GAS TRANSMITTER; L - ELECTRIC COOLER; M - DRYING COLUMN /$CaCl_2$/; N - ROTAMETER.

The basic functions of the system are:

I. Sequential measurement of temperature, relative air humidity, CO_2 concentration, and intensity of PhAR energy in greenhouse chambers.

2. Maintainance of programmed CO_2 concentrations in the different chambers during determined period of the day.

3. Stopping the, CO_2 feeding when the light intensity dropped below a programmed level (30 W. M -) and switch an the feeding when the light intensity exceeded this level.

4. Teletyping the measured magnitudes and perforating them on a tape for further electronic processing.

Moreover, the system anables a rapid change of the basic parameters such as the time of the measurement cycle, CO_2 concentration in the different chambers etc..

Every 90 sec. the temperature, relative humidity, CO_2 concentration, and PhAR energy were measured by the system in one chamber (the so called small measurement cycle), the obtained data being teletyped and perforated. Six sensors

were used, one outside the greenhouse and five inside the chamber at various height, this making it possible to compare the light energy reaching greenhouses and plants of different height. Pressler TIJMU 320 GKV photocells, equiped with corrective filters equilizing their sensitivity for the PhAR range, were used as light sensors. The measured short lived intensities of this light were integrated by the CANAC system. The CO2, concentration measured in the chamber fed with this gas was compared by the system with the programmed magnitudes and in the case of lower concentrations the electronic valves were opened. The time of CO, feeding was proportional to the concentration difference calculated by the system. A comparison of recorded PhAR energy with the programmed magnitude occurred simultaneously and when the measurement revealed values Lower than the programmed ones, the CO_2 feeding **was** not begun.

Eight small measurement cycles, leasting 12 minutes, from a large measurement cycle comprising all chambers; during 24-hour work the programe comprised 960 small cycles, ending the daily cycle with a unperforated sector of the tape and a few empty lines in the printout. The results of measurements were teletyped as decimals and perforated in the ASCII code. Both, the printed and perforated results are presented in conventional Values. Standard curves which are available in the system equipment, are used for the conversions of these values to the magnitudes in suitable units (°C, % **F1≥0,** vpm CO,, W m), while in the data processing from the perforated tape, the programme intrudes the computation of the magnitudes into these units.

3. Production effects of CO_2 enrichment **in** greenhouse tomato growing

Durign the first years of experiments varied CO, concentrations were used in individual chambers (800, 1200 and 1500 vpm), such other factors as temperature, light, humidity, and fertilization being maintained at a determined level. In all cases the CO, fed tomatoes gave higher yields, 1500 vpm being found most effective. This level of CO2 enrichment was applied in further experiments. Significantly better yields were obtained in the spring production season than in the autumn-winter one.

In the two seasons 3 greenhouse tomato cultivars were used in the experiments: Revermun, Reverdan, and Pagham Cross. The CO_2 concentration was 1500 vpm fed from 10 a. M. to 4 p. M. when the light conditions were suitable. Ventilators with moving heads were used for mixing CO_2 with air in the greenhouse. The COfeeding was begun after tomatoes were transplanted in the chambers. Phytometric measurements carried out on tomatoes grown in enriched atmosphere showed that the plants grew properly during the vegetation season.

Table 1

Coefficient of yield earliness of greenhouse tomatoes grown under CO_2 enrichment/ index of earliness expressed in days, counted according to Reinhold method/.

Spring season 1978

	Cultivars		
	Revermun	Reverdan	Pagham Cross
I replication	132,24	131,42	127,06
II replication	126,53	126,48	107,79
III replication	125,77	131,68	124,78
IV replication	130,57	130,12	126,49
- of 4 replications	128,78	129,92	121,53

Revermun/standard cultivar/: 1973-75 : 133.

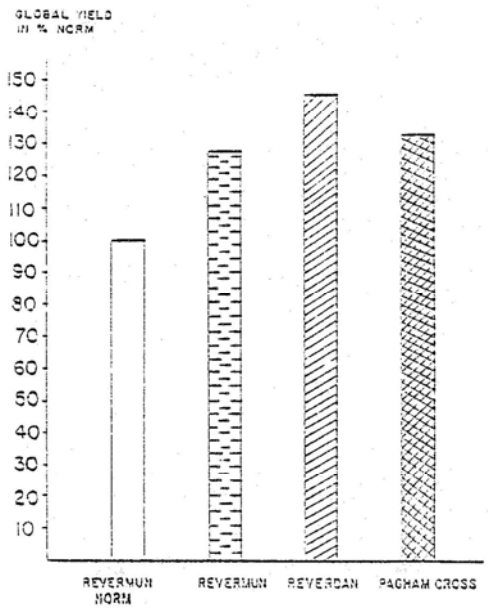

Fig.6. YIELDS OF 3 GREENHOUSE TOMATO CULTIVARS GROWN IN SPRING SEASON AT A CO_2 LEVEL OF 1500 ppm.

In the investigated cultivars total fruit yields ranged from 10,08 kg/sq. M. - 11,41 kg/sq. M. According to the experimental procedure recommended by the Investigation Centre of Culture Plants Cultivars at Slupia Wielka (Poland) the Revermun cv was used as standard for yield comparison. In comparing the yields obtained in our experiments with the standard or it was found that in CO_2 fed tomatoes total yield increases were 27,5% for Revermun cv, 45,2% for Revirdan cv, and 33,22 for Pagham Cross cv (Fig.6). Upon analysing the earliness of yields (Tab. L) it was found that the earliest crop was obtained with Pagham Cross•cv, with a difference of 12 days in comparison with the standard cv. Revermun and Reverdan cvs yielded 5 days earlier on the average.

Further investigation will concern theoretical and practical aspects of C4 enrichment of other greenhouse crops as well as attempts to find inexpensive available CO_2 sources.

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XVI. MORPHOGENESIS OF EARLY LETTUCE UNDER TEMPORARY DIRECT COVER OF PERFORATED PLASTIC SHEETING

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The cropping of lettuce at the and of May can be advanced by applying a flat cover of perforated P. E. Sheeting (0,05 am thick, holes of 1 cm in diameter) during a certain length of time after planting out at the end of February.

It appeared that each degree of perforation (11 to 800 holes per square meter) is linked up with an optimum period of covering (15 to 40 days).

It may generally be taken that the optimum length of the time of cover applied is directly proportional to the intensity of perforation.

The optimum time of cover is also dependent on the length of the plant"s vegetative stalk, the number of leaves and their length/width ratio. This relation (L/W) should be as small as possible because maximum development can only be reached by a limited number of wide leaves, i. E. with a very low L/W ratio (;$ 1), these leaves determining both the weight and the quality of heads.

C. V. Reskia (R. Zwaan) produces a longer plant stalk and shows a more pronounced Nratio than C. V. Suzan (Pannevis).

That is the reason why C. V. Reskia responds much beter to direct covering than C. V. SUZAN.

INTRODUCTION

From earlier trials (Benoit & Hartmann 1974, Benoit 1975) it has appeared that direct covering with perforated plastic sheeting should only be applied to early Lettuce grown outdoors during a well determined length of time. Too long periods of cover resulted in smaller head weights.

Seitz (1973, 1974) and Frits (1977) found that more intensively perforated sheeting (150 to 1.200 holes) could be applied longer, but 40 to 50 days was the extreme limit.

FIGURE I.

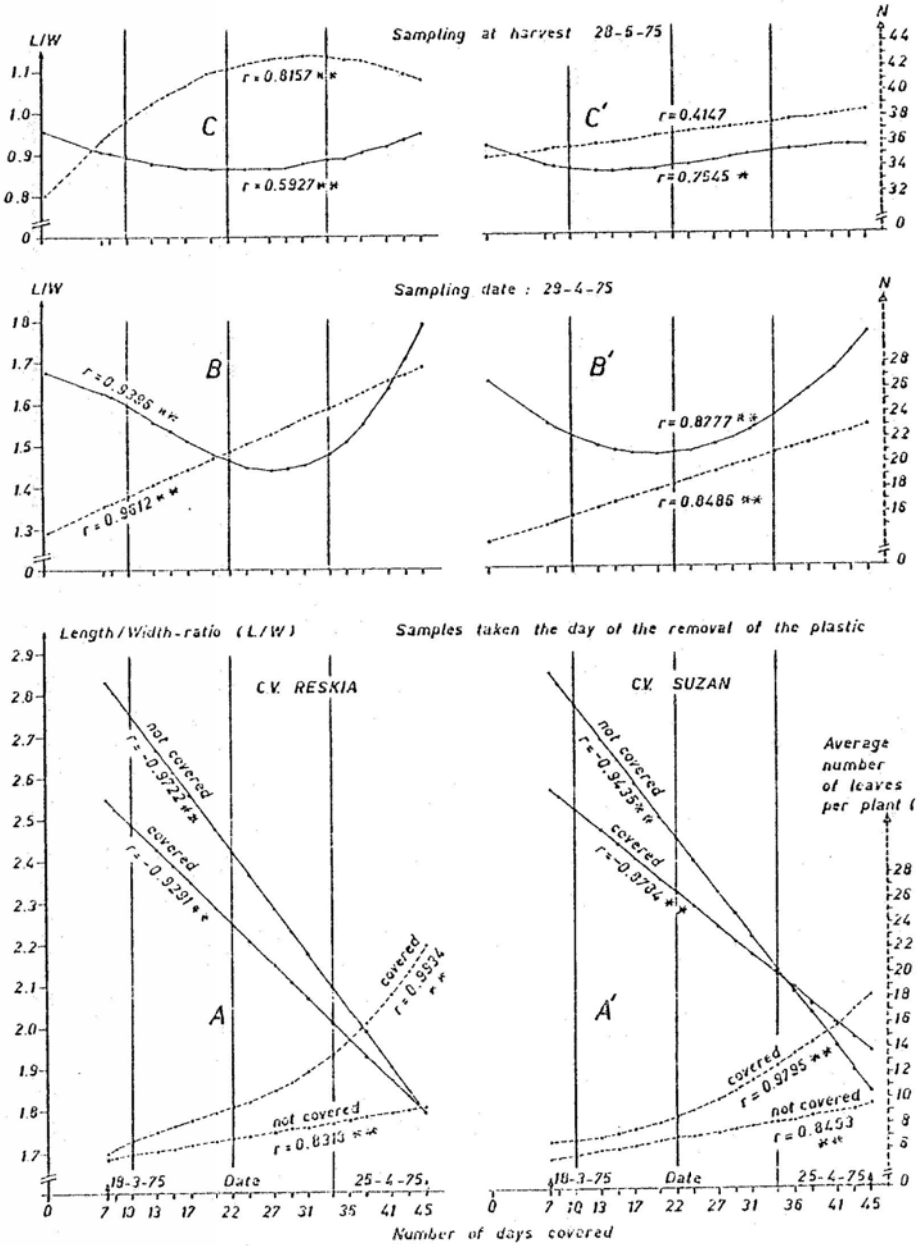
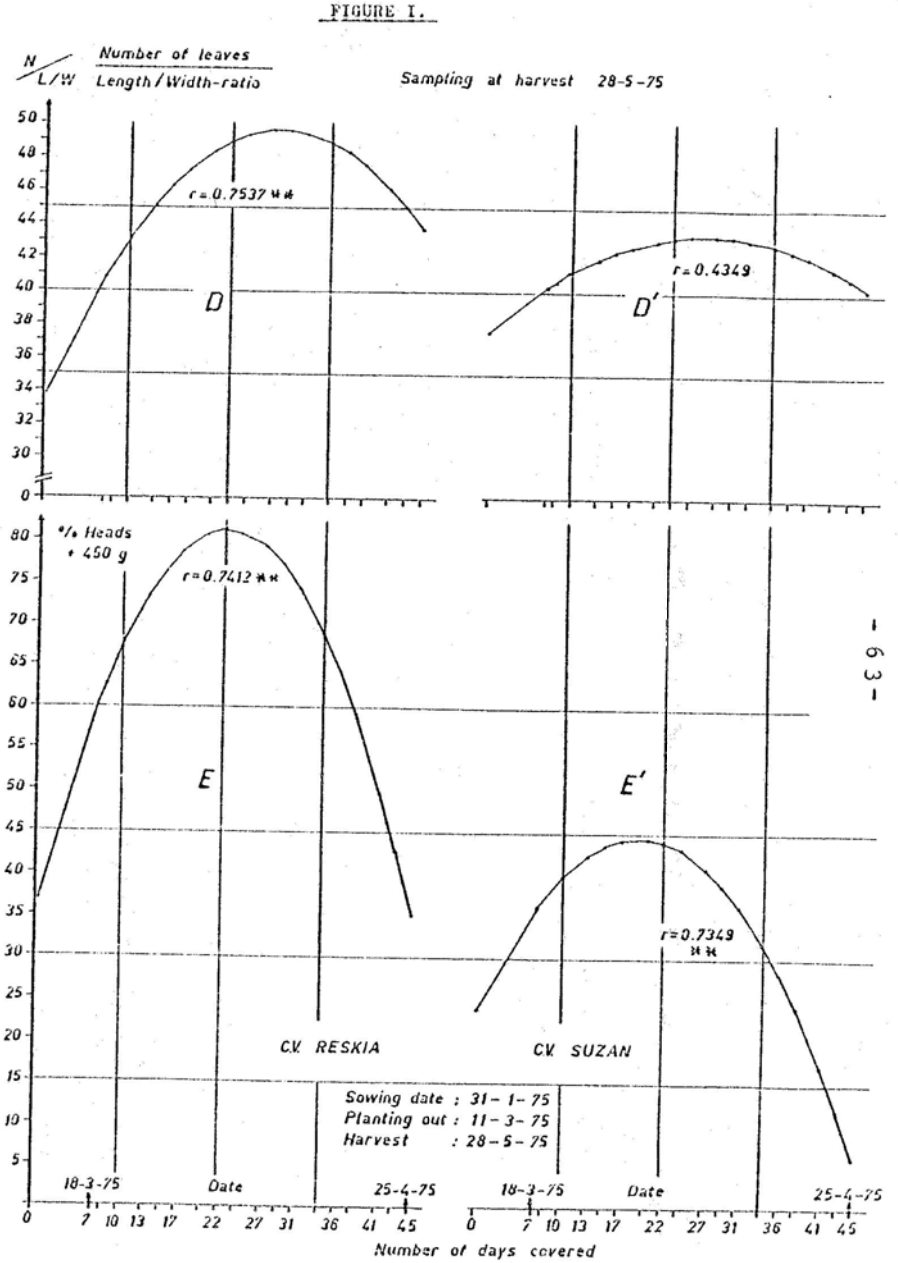


FIGURE I.



The object of the present trials was to determine the effect both of the intensity of perforation and of the length of the covering period on the optimum development of early lettuce.

MANAGEMENT

Trials of 1975. The lettuce cultivars Reskia (Rijk's Zwaan) and Suzan (Pannevis) were sown on 31 January and planted out in press pots of 4,5 cm under cold ***glass*** on 17 February. On 11 March they were placed in a block design with 2 replications and a spacing of 30 by 30 cm.

Immediately after planting out, they were covered with PE sheeting of 0,05 mm with perforations of 1 cm in diameter, spaced at 30 cm. The intensity of perforation therefore came to 11 holes pei square meter, or 0,09 per cent.

A comparative study ***was*** made of 19 treatments, viz of the uncovered control plot and those covered with the above mentioned type of plastic sheeting during 7, 8, 10, 13, 15, 17, 20, 22, 24, 27, 29, 31,34,36, 38, 41, 43 and 45 days respectively. Each length of sheeting covered 4 rows of plants, and was on two sides burrowed 10 cm deep in the ground. The sheeting was not drawn tight buc was laid slackly over the plants, in such a way, however, that it did not flutter.

The first recordings, including those of the number of Leaves (N) and their length-width ratio (L/W), were always made on the day when the covering was removed. The same assessments were always made of uncovered plants of a corresponding age.

A second assessment of all plots was carried out on 29 April, i. E. 49 days after planting out.

Finally, a third measuring was carried ont on 28 May, i. E. 78 days after planting Out.

The counts and measurings were always made of 4 plants per plot and per replication, and of 8 plants for determining the weight of heads at the time of harvesting.

Trials of 1976

The lettuce C. V Reskia (Rijk's Zwaan) was sown on 28 January 1976 and planted out in press pots of 4,5 cm under cold glass on 11 February. On 15 March the plants were placed in a block design with 3 replications and a spacing of 30 by 30 cm.

The control plots were not covered, Plastic sheeting of 0,05 cm thickness with perforations of 1 cm in diameter was applied on the others. The perforation percentages were 0,09 (11 holes/ m2), 0,35 (44 h/m2), 3,1 (400 h/m2) and 6,3 (800 h/m2) respectively.

Each type of sheeting was placed over the plants directly after planting, and removed after 10, 2o, 30, 40 and 50 days.

On 21 May, 2 plants of each plot and per replication were assessed for their L/W ratio, number of leaves, etc. For determining the fresh weight, 16 plants per plot and per replication were taken.

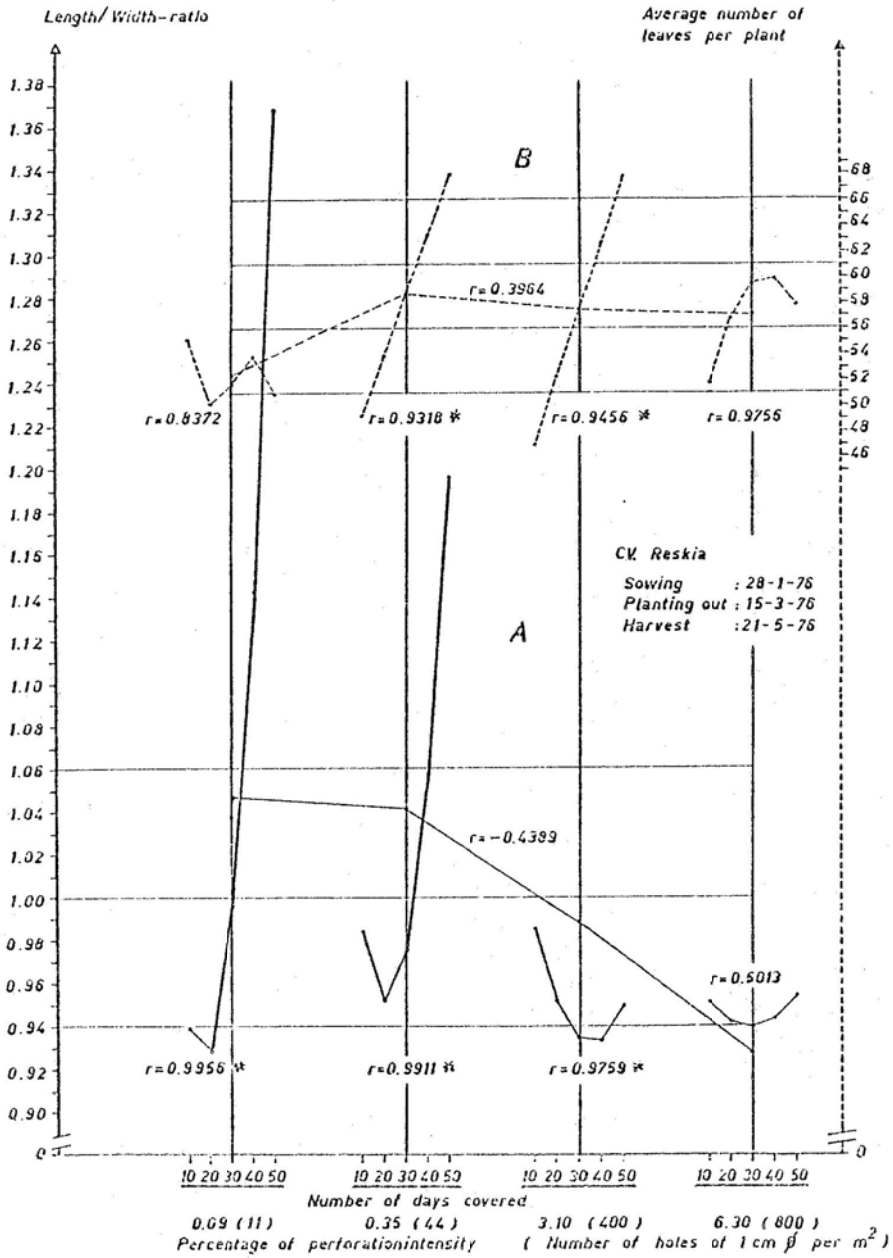
RESULTS

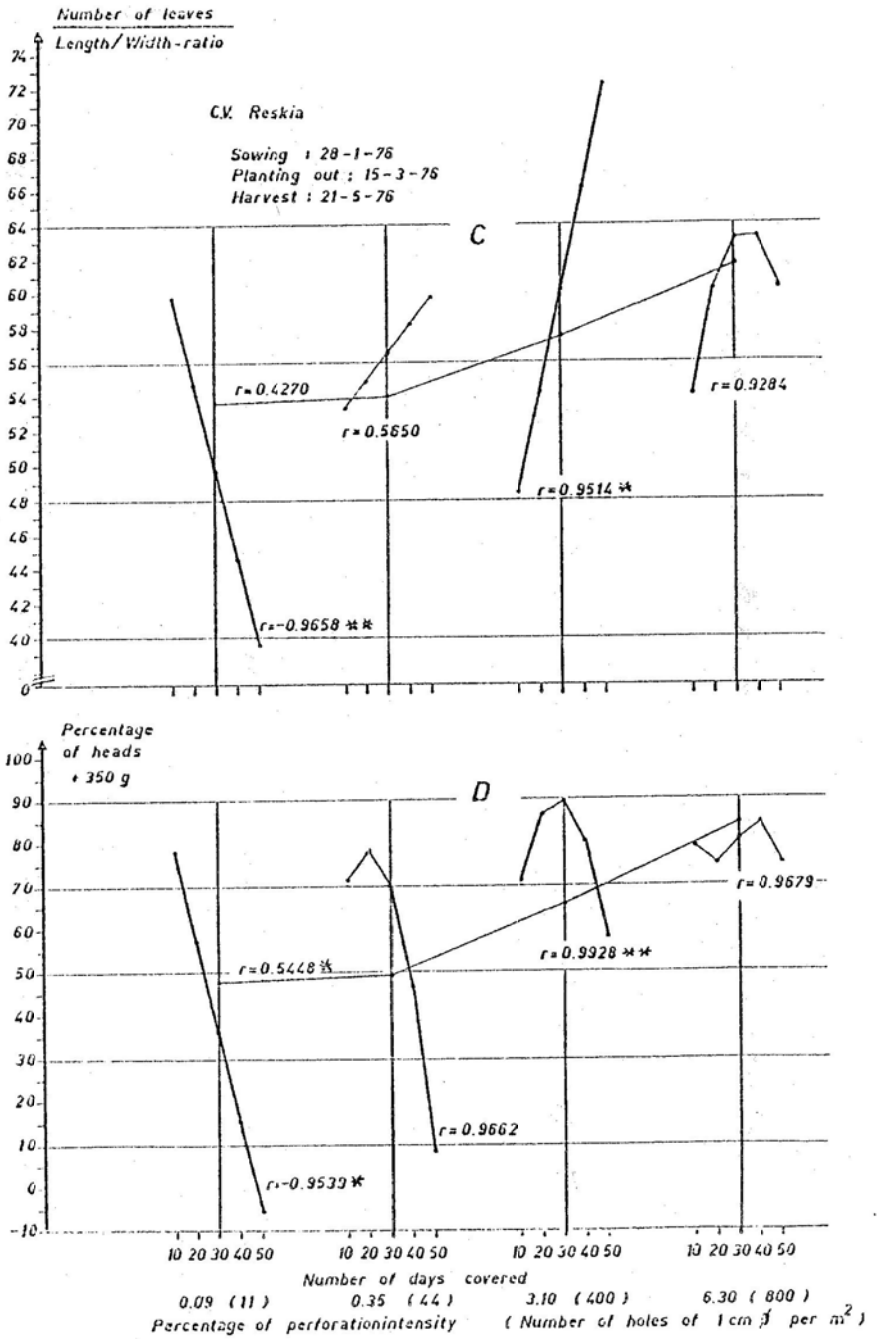
Trials of 1975. Plastic sheeting of 0,05 mm thickness and a perforation intensity of 30 holes of 1 cm in diameter per square meter was used exclusively.

Figures 1 A and A' show the number of Leaves (N) and the length/width ratio (L/W) obtained. All recordings were made on the day when the covering was removed.

It appears clearly that under plastic cover, the number of leaves increases more rapidly between the 7th day (18.3.75) and the •5th day (25.4.75). The L/W ratio is smaller and therefore more favourable.

FIGURE 2.


Length/Width-ratio
Average number of leaves per plant
B
r = 0.3964
r = 0.8372
r = 0.9318 *
r = 0.9456 *
r = 0.9756
C.V. Reskia
Sowing : 28-1-76
Planting out : 15-3-76
Harvest : 21-5-76
A
r = -0.4389
r = 0.5013
r = 0.9956 *
r = 0.9911 *
r = 0.9759 *
10 20 30 40 50
Number of days covered
0.09 (11)
0.35 (44)
3.10 (400)
6.30 (800)
Percentage of perforationintensity
(Number of holes of 1 cm ∅ per m²)


Number of leaves
Length/Width-ratio
C.V. Reskia
Sowing : 28-1-76
Planting out : 15-3-76
Harvest : 21-5-76
C
r = 0.4270
r = 0.5650
r = 0.9514 *
r = 0.9284
r = -0.9658 **
Percentage of heads + 350 g
D
r = 0.5448 *
r = 0.9662
r = 0.9928 **
r = 0.9679
r = -0.9539 *
10 20 30 40 50
Number of days covered
0.09 (11)
0.35 (44)
3.10 (400)
6.30 (800)
Percentage of perforationintensity
(Number of holes of 1 cm ∅ per m²)

C. V. Reskia produces more leaves than C. V. Suzan, whether the plants are being covered or mot.

In the uncovered plots no significant differences in L/W ratio were observed between the two cultivars used. However, the leaves of Reskia grown under cover were wider.

Figures 1 B and B' show that on 29.4.75, i. E. 49 days after planting out, the course of the L/W ratio tends to the ideal minimum, whereas the number of Leaves continues to increase.

No difference in the form of leaves was observed between the two cultivars used, but the number of leaves produced by Reskia was larger.

The sampling at the time of harvesting (28.5.75) showed a continuation of the tendencies observed in the previous samplings (Fig.1 C aad C').

The N ratio (Fig.1 P and 0') clearly shows an optimum development, which is reflected in the crop weight (Fig.' E and E').

It is obvious that the overall results of C. V. Reskia were significantly better than those of C. V. Suzan. It is also clearly apparent that the best results were obtained by applying the sheeting with11 perforations per square meter for about 22 days.

Trials of 1976. Plastic sheeting of 0,05 mm thickness and with various degrees of perforation was used here for covering lettuce during 10 to 50 days after planting out.

It appears that the course of the L/W ratio at the time of harvesting (Fig.2 A) tends to the ideal minimum for every degree of perforation. With a smaller intensity of perforation (11 and 44 holes per m2) the broadest leaves were obtained by covering the plants for 20 days only, with a higher degree of perforation (400 and 800 holes) the broadest Leaves were obtained after 30 to 40 days. The L/U ratio, however, did not decrease with increased perforation.

The number of leaves (Fig.2B) did increase with the length of time of covering but was not influenced by the degree of perforation.

The N/(L/W) curves (Fig. 2C) do not - as in 1975 - show an optimum development but seem rather to develop similarly to the N curves (Fig.2 B). This, however, was influenced by the extent of the time of covering, and not by the intensity of perforation.

Optimum developments in head weight did occur, and they are apparently inversely proportional to the L/W ratio. Heavier heads were indeed obtained by increasing the intensity of perforation, but in that case the period of covering had to be extended as well.

Table I shows that direct cover produced a signficant increase in the length of stalks in several plots, and also that the stalks of C. V. Reskia were longer than those of C. V. Suzan.

TABLE I - Length of the vegetative plant stalk at the time of harvesting.

FLAT PLASTIC COVER PERFORATION INTENSITY COVERING TIME	LENGTH CF VEGETATIVE STALKS IN CM	
	RESKIA	SIJZAN
NOT COVERED	3,76 d(x)	3,31 (x)
COVERED		
400 holes - 30 days	5,03 b	4,63 (z)
40 days	5,64 ab(y)	
8OO holes - 30 days	4,15 c	
40 days	5,15 ab	
50 days	5,70 ab	

a to d : significant = 0,05) differences between treatments in Reskia

(x to z) : significant (P = 0,05) d4'40-ences between cultivars.

Wilen correlating further data it appeared, amongst other things, that the length of stalks correlated very positively with the number of leaves and the average weight of heads.

DISCUSSION

Former trials (Benoit, 1975 and Benoit & Hartmann, 1974) have shown that lettuce should be covered during 21 days only, when using plastic sheeting with 11 to 44 perforations per square meter. Both shorter and longer periods of covering resulted in less favourable head weights. Also, shorter periods of cover were required at Geinsemheim/Rhein (G. F. R.) than in St Katelijne Waver (Belgium), because in Germany there was less wind, more sun and temperatures were higher (Benoit et Hartmann , 1975).

In the present trials, definite weight optima were obtained.

These optima are determined by the type of C. V. used, the intensity of perforation of the sheeting and the corresponding time of cover. Smaller perforation intensities (11 and 44 holes/m2) must correspond with shorter periods of cover (10 to 20 days), and more intensive perforation (400 and 800 holes) with more extensive periods of cover (30 to 40 days).

From the present trials it appeared further that the morphogenesis of lettuce is chiefly contingent upon the L/W ratio of its leaves, which confirms the results of earlier research by Bensink (1971). It is therefore certain that the leaves of lettuce will not show a minimum L/W ratio unless the optimum time of cover has been applied.

We suggest the following explanation of this optimum effect. Prolonged periods of cover cause the length of stalks and the number of leaves to increase, while the L/W ratio of leaves is reduced.

The increase in weight of heads is due to the Larger number of broad leaves (i. E. smaller L/W ratio) , whose production is facilitated by the greater length of the plant stalks. If, however, the time of covering is too extensive an excessive number of leaves will develop on relatively small stalks. Owing to lack of space, the leaves will tend to increase in length (higher L/W ratio). The heads will therefore be looser and their leaves will have an increased capacity to transpire, which in turn results in reduced head weight.

Zengerle and Kretschmer (1973) also observed that temporary flat covering caused a firmer and more compact structure of heads.

Both from earlier research (Benoit et al. 1974, Benoit 1975) and from the present trials (Comitd 1976, 1977) it appears that the average fresh weight of leaves corresponds to the weight of heads. The average dry weight, however, decreases with the length of time of cover. This confirms the opinion that an increased weight of heads must be attributed to increased water retention.

The young plants, when covered, grow under increased ranges of temperature (Benoit et al. 1974, Benoit 1975) which ameliorates root developmen(Van der Post et al. 1960, Benoit 1975) and causes the number of leaves to increase and their L/W ratio to improve (Bensink 1971).

Increased root development enables the plants to absorb more water, which results in better head weights. If, however, the heads are too loosely structured because the number of leaves is too great, too large amounts **of** water will be lost through transpiration.

ACKNOWLEDGEMENTS

The present research work **was** subsidized by the I. W. O. N. L., Belgium (Institute for the Promotion of Research in Industry, Agriculture and Horticulture). The analysis of statistics was carried out by A. Calus, of the Bureau of Biometry of the University of Ghent.

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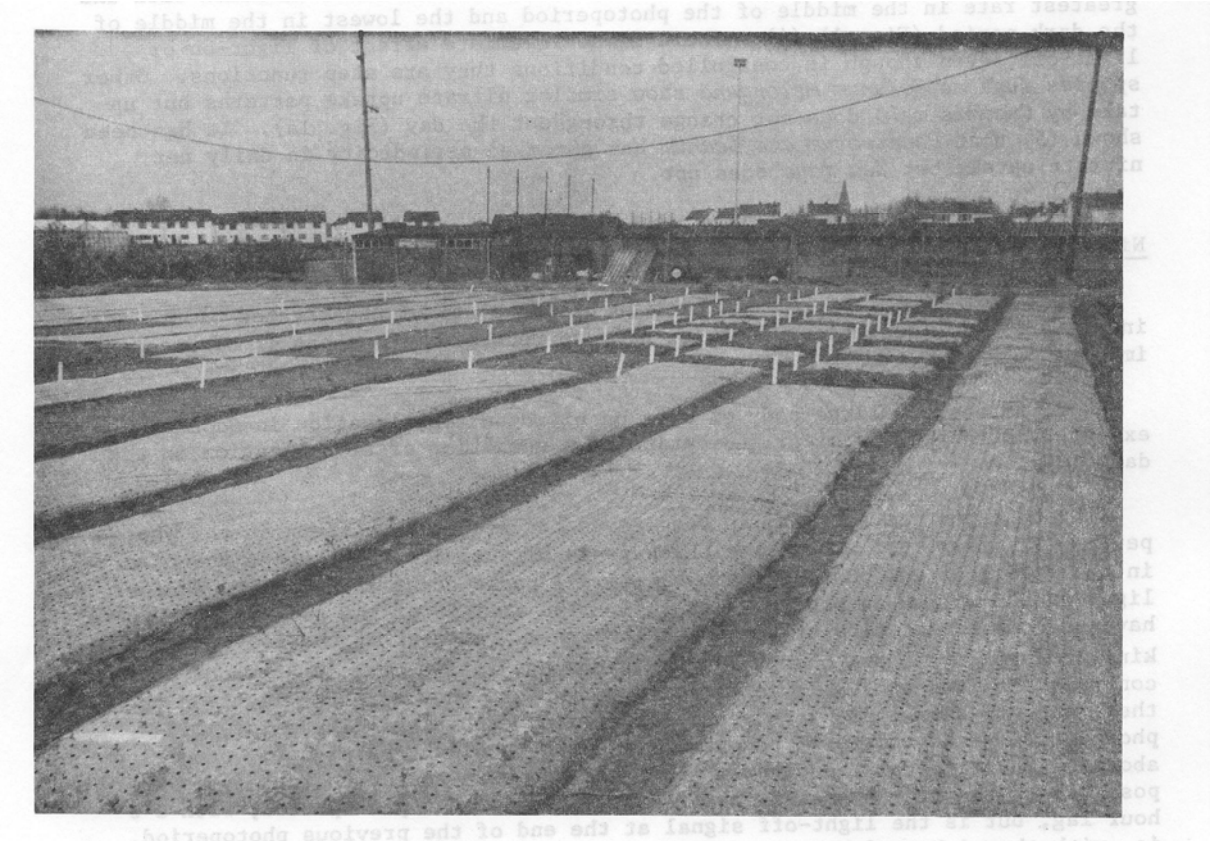

XVII. DAILY NITROGEN METABOLISM IN CAPSICUM ANNUUM

Barrie T. Steer
CSIRO Division of Irrigation Research, Griffith, NSW 26804 Australia).

Investigation of the change in the activity of a number of plant functions throughout a 24 hour cycle has enabled us to identify some points of metabolic integration in the whole plant. The work deals with aspects of nitrogen metabolism from nitrate acquisition to nitrate reduction and protein synthesis. Although some of the findings may be species-specific the interpretation of the results and the conclusions should add to our understanding of plants in general.

The species used in the studies was *Capsicum* annuwn cv. California Wonder grown in glasshouses or controlled environment cabinets. The experiments were always carried out in controlled conditions. The results have been summarised recently (15) and I report here the main findings and add new interpretations where applicable.

Acquisition of nitrogen

Nitrate uptake in *Capsicum* annuwn is not constant throughout the day. Both ^{14}N and ^{15}N studies have shown that uptake fits to a harmonic function with the greatest rate in the middle of the photoperiod and the lowest in the middle of the dark period (Fig. 1) (4). There is no immediate effect of light-on or light-off, even though in controlled conditions they are step functions. Other species such as *Solanwn melongena* show similar nitrate uptake patterns but uptake by *Cucumis melo* does not change throughout the day (Fig. la). It has been shown (5) that *Pennisetum americanum* has a marked periodicity in daily net nitrate uptake but *Zea mays* does not.

Nitrate reduction

In *Capsicum* 80-85% of the nitrogen in bleeding sap of decapitated plants is in nitrate (12), suggesting that for nitrate reduction the shoot is of greatest importance.

We do not have a large body of data on nitrogen translocation in *Capsicum* except that there is a clear indication of a cessation of translocation in the dark (4).

Nitrate reductase activity in the leaves has a complex pattern in the photoperiod (Fig. 1) (13). There are three peaks of activity. The major one occurs in the middle of the photoperiod, while small peaks occur about one hour after light-on and within an hour of light-off. The timings of the two small peaks have the characteristics of circadian rhythms. Treatment of the leaves with kinetin invokes a phase change in the rhythm but little more is known of the controls involved (14). It is tempting to suppose that both the light-on and the light-off signal are involved in the timing mechanism. The major, mid-photoperiod peak appears to be associated with the light-on signal; occurring about six hours after the signal. What has not been tested thoroughly is the possibility that the signal is not the beginning of the photoperiod, with a 6 hour lag, but is the light-off signal at the end of the previous photoperiod, ie. with the night 4- 6 hour lag.

Although these patterns of nitrate reductase activity have been obtained by in *vitro assays, in vivo* confirmation has been obtained by data on the size and ^{14}C labelling (Fig. 1) of leaf amino acid pools (12). Thus all three nitrate reductase peaks are paralleled by changes in amino acids, although the relative effectiveness of the enzyme peaks may differ (Fig. 1).

From the foregoing it is evident that net nitrate uptake and leaf nitrate reduction do not have a close association within the 24 hour cycle. This independence from one another has been confirmed by an experiment in which nitrate was provided to plants in the tenth hour only of the photoperiod. This time-limited nitrate supply did not cause a shift in the major nitrate reductase peak from the sixth hour even though most nitrate was translocated to the shoot when it *was* acquired, in the tenth hour (4). Thus *Capsicum* differs from species such as maize in which leaf nitrate reductase is controlled by the flux of nitrate from root to shoot (10).

Protein synthesis

The next stage studied in the metabolism of nitrogen is protein synthesis. This has been achieved indirectly by measuring the polyribosome content of leaves throughout the 24 hour cycle (16). In some tissues the Z ribosomes present as polysomes gives a good indication of the rate of protein synthesis when different conditions are compared (see 11); this assumption *is* made for *Capsicum* leaves. Of greatest interest is the finding that the 24 hour pattern in leaf polyribosome content is a harmonic similar to that for nitrate uptake

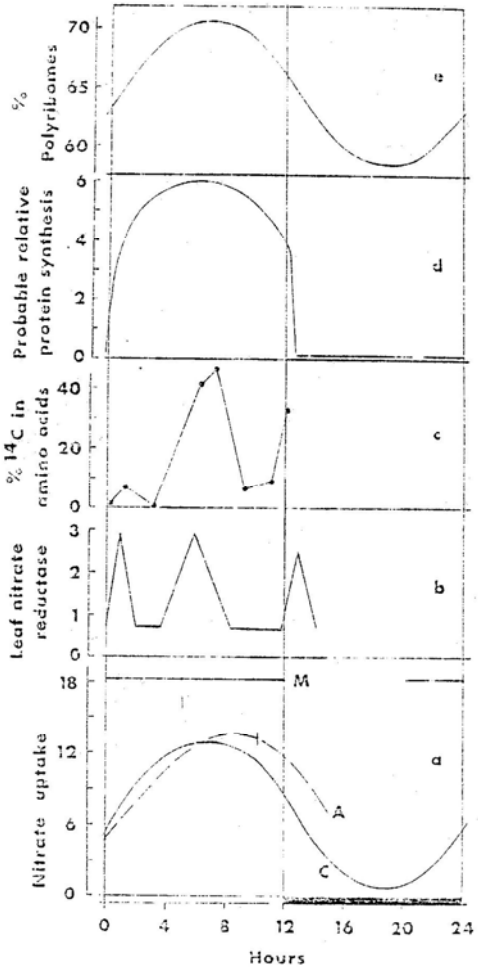

Figure 1

a) Nitrate uptake by the whole plant: µg NO_3-N h^{-1} g^{-1}FW. C: *Capsicum annuum* cv. California Wonder (ref 4); A: aubergine, *Solanum melongena* cv. Supreme in 10 hour photoperiod; M: Melon *Cucumis melo* cv. Hales Best.

Capsicum annuum

b) stylized pattern of leaf nitrate reductase activity (ref 14, 14).

c) % total ^{14}C recovered in amino acids after 5 min exposure of leaves to $^{14}CO_2$ (ref 12).

d) suggested pattern of protein synthesis (after ref 4, 16).

e) polyribosome content of leaves as % total ribosomes (ref 16).

with a peak in the middle of the photoperiod and a trough in the middle of the dark period (Fig. 1). It bears ao resemblance to the pattern of leaf nitrate reductase activity. However, the polyribosome level in the dark trough is about 60% of the total ribosomes, implying a significant capacity for protein synthesis even in the dark. Accordingly, the polyribosome content should be viewed as the potential capacity for protein synthesis and not as a measure of actual synthesis, because ^{15}N data show that little nitrogen incorporation into protein occurs in the dark period (1, 4). In the dark it is likely that reduced protein synthesis from inorganic nitrogen occurs through the limitation of nitrogen translocation and reduction. This interpretation is consistent with the finding that incorporation of isotopically labelled methionine into proteins by *Capsicum* leaves occurs at a lower rate in the dark than in the light. Further, there is little difference in the relative labelling of individual proteins in the light and dark except in two membrane proteins and possibly in the large subunit of Fraction I protein (16).

Table 1
Predictors of nitrate uptake rate over 24 h:

		% variation in uptake accounted for	
Root carbohydrate	20	-1.8	0.66
Root sucrose	9	-14.2	0.005
Root malate	9	50.2	9.07*
Leaf total adenosine phosphates	8	7.0	1.52
Leaf Z polyribosomes	11	41.3	8.04*

* = $P<0.05$

Nitrate uptake rates taken from fitted curve. Levels of predictors are experimental values (Taken from ref. 4, 15, 16).

Table 2
% distribution in roots of ^{14}C translocated from presentation leaf

5 min $^{14}CO_2$ at:	Start-		Mid-		End-photoperiod	
Hours chase	0.75	5	0.75	5	0.75	5
Roots	1.3	17.2	2.6	21.2	2.5	20.3
Root carbohydrate	0.1	12.4	1.2	14.4	1.2	16.6
Root insolubles	1.2	2.9	1.3	3.8	1.0	1.9
Nitrate uptake ug NO_3-N h^{-1} g^{-1}FW (from Fig. la)	7	12.5	13	--10	9	8 -N. 1

	Roots after 5 hours		
Fed at:	Start-	Mid-	End-photoperiod
% ^{14}C in sucrose	6.76	9.23	10.26
in fructose	2.53	2.33	3.44
in glucose	3.12	2.87	2.96
dpm ug^{-1} sucrose	1.12	1.32	1.30
fructose	2.40	4.53	1.93
glucose	1.47	1.55	0.92

Unpublished data of Steer & Pearson

Root/shoot control

The maintenance of the polyribosome population and the rate of nitrate uptake have similar 24 hour patterns, which suggest a common control. Expressed in another way, this similarity is one manifestation of a balance in nitrogen metabolism between root and shoot. This balance is often seen as a control by the shoot of ion uptake by the root. The messenger or effector of this balance is suggested to be the supply of carbohydrates to the root by the shoot (eg. 6). In *Capsicum* neither root carbohydrate nor root sucrose show a significant correlation with nitrate uptake rate (Table 1). Neither does ^{14}C translocation from leaves to the root show differences at times in the photoperiod when nitrate uptake rates are different (Table 2). The one property that does show a significant correlation with nitrate uptake rates is the level of root malate (Table 1). This correlation suggests that malate may be the shoot to root messenger but in the widely accepted scheme (7) malate originates at the reduction of nitrate to amino acids in the leaf. By this scheme malate will not be a link between protein synthesis and nitrate uptake. Also the idea that some charge balancing at nitrate reduction is by immobile anions (3) would remove any stoicheiometry between malate and nitrate reduction, making malate transport a poor coordinator between shoot and root.

Possibly nitrogen metabolism in the shoot and the root is coordinated by growth regulators. However, the application of abscisic acid and cytokinins to roots alters xylem loading but not total ion uptake (2). Thus the available information on regulation of nitrate uptake in the whole plant is not extensive enough to allow an unequivocal conclusion about its mechanism. The data from measurements of plant functions throughout a 24 hour cycle are evidence against the supply of carbohydrates to the root being the coordinating messenger but do not provide clear evidence of an alternative mechanism.

Control of nitrate reductase patterns

We cannot offer explanations for the control of functions having harmonic patterns in the 24 hour cycle; can we for the distinctive pattern of leaf nitrate reductase activity?

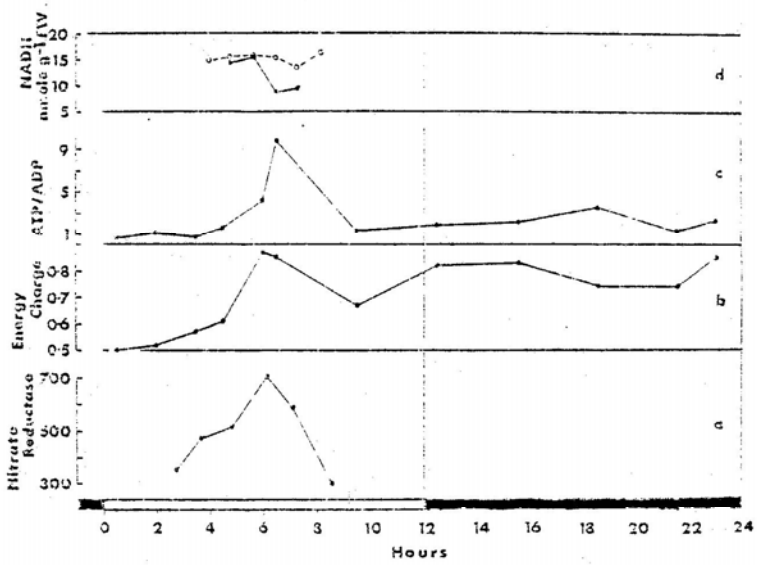

Figure 2. Daily changes in leaves of *Capsicum annuum*
a) nitrate reductase activity: nmole h^{-1} cm^{-2} lamina (ref. 13).
b) energy charge: ATP + 0.5 ADP/ATP + ADP + AMP (ref. 15).
c) ATP/ADP ratio (ref. 15).
d) NADH levels ●——● cv. California Wonder.
o- - -o cv. Yolo Wonder.

Measurements of the contents of adenosine phosphates in *Capsicum* leaves (15) have shown that the ATP/ADP ratio has a large increase in the middle of the photoperiod; at other times it stays almost constant. The pattern of energy charge is similar in some respects but is altered by a steady decline in AMP content throughout the photoperiod and a constant low level in the dark period. In contrast to ATP/ADP the energy charge remains high late in the photoperiod and throughout the dark period. The peak in ATP/ADP and the increase in energy charge in the middle of the photoperiod coincide with the major nitrate reductase peak (Fig. 2). This correlation may be explained in terms of the recent hypothesis advanced by Sawhney, Naik and Nicholas (8, 9) to explain the cessation of nitrate reduction in the dark (1). In the mid-photoperiod the high ATP level will inhibit the mitochondrial electron transfer chain from NADH to oxygen. The unconsumed NADH is then used for nitrate reduction.

The use of this hypothesis in interpreting the *Capsicum* results leaves some questions unanswered: 1) The low energy charge, and ATP/ADP, early in the photoperiod can control nitrate reduction through mitochondria' activity but late in the photoperiod enzyme activity decreases without a concomitant decrease in energy charge. 2) How do the two small circadian peaks of nitrate reductase activity function at times of low ATP/ADP, unless they are radically different in response or location to the major peak? Another important question is what environmental or physiological signal is involved in the timing of the mid-photoperiod peak of ATP/ADP and energy charge. There are no answers to these questions at the moment. What is implicit in the interpretation made above is that *Capsicum* leaf metabolism, particularly Mitochondria' activity, is different in the early photoperiod to that *in* the mid-photoperiod both of which are different again to the late-photoperiod.

Measurements of a number of metabolic functions throughout a 24 hour cycle have enabled us to demonstrate some control mechanisms whereby nitrogen metabolism in the whole *Capsicum* plant is integrated. It is hoped that future ^{15}N studies will provide more information on the dynamics of nitrogen metabolism in *Capsicum,* particularly *in* the roots and in translocation to the shoot.

Species comparison, in addition to that available for terrestrial plants such ***as*** maize and melon, will be afforded by another research program on emergent aquatic *species.*

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KVIII. LABORATORY MATERIAL

R.2963 Research Bulletin. Constructing a continuous circulation system for plant solution culture.

T. W. Tibbitts, D. A. Palzkill and H. M. Frank

In the Phytotronic Newsletter n°14 (november 1946) pages 95-96 we have published description of "Automated liquid culture system".

In december 1978 the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin Madison, publishes this information in support of its programs and provides equal opportunities in employment, programming and admission. Single copies of this publication are available free to Wisconsin residents from county Extension Offices and to others from the Agricultural Bulletin Building , 1535 Observatory Drive, Madison, W1 53706. The Agricultural Bulletin Building quotes prices for bulk orders.

XX. NEW BOOKS

a. LIGHT AND PLANT MURPHOGENESIS

This book edited in 1978 by F. N. Kuperman and E. I. Rjanova, University of Moscow (USSR Moscow K-9, Herzen Street a 5/7), is a collective monograph of 188 pages. The Table of Contents includes subjects dealing with the influences of light periods on the morphogenesis of different plants. This is the results of research done over a number of years on Plant Development Laboratory, particulary on photoperiodism, the intensity and spectral quality of light and the morphogenetic processes in different organs of cultivated plants. There are studied about the differentiation of terminal meristems at the moment of passage from a vegetative to a generative state, as well as growth and morphophysiological variations of ontogenesis in different lighting remimes. This book is destined for biologists, physiologists, ecologists and plant breeders as well as for those in higher education. The book, unfortunately, *is* in Russian with no English summary.

Table of Content:

F. M. Kuperman. Research of morphogenetic laws of plants done by studying cultures under different lighting regimes.
E. I. Rjanova. Reactions of cultivated species of vetch under different lighting regimes.
V. A. Akundova. Potential productivity and actual formation of fruits of beans under different lighting conditions.
Z. P. Rostovtzeva. Influence of plants' photoperiodic reaction on the working of the terminal meristem in vegetative and prefloral organogenesis.
I. N. Lvova. Influence of the lighting regime on the morphogenesis of different varieties of Cucumber.
E. A. Sedova. Horphophysiological study of the photoperiodic reaction of Gladiolus hybridus hort.
A. I. Tzeliadinova. Morphophysiological modifications in certain species of shrubs under different lighting regime .
I. C. Isaieva. Growth and Development of the apple-tree under different lighting regimes.

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b. ROOT PHYSIOLOGY AND SYMBIOSIS

Editor. A. Riedacker and J. Gagnaire-Michard. CNRF. Station de Sylviculture. Champenoux 54280. Seichamps (France).

This book is the volume 6 of "Comptes Rendus *des* Reunions du groupe d'atude des racines" held at Nancy (France) at september 11-15-1978 (450 pages. Price 160,50 FF) and contents following communications gathered in six chapters.

I. CARBOHYDRATES METABOLISM AND ROOTS PHYSIOLOGY

I. I. Les glucides metaboliques. Interet de leer -etude dans les racines
F. Barnoud (France)

1.2. Seasonal changes in root growth capacity and carbohydrates in red PINE and white spruce nursery seedlings.
R. Van den Driessche (Canada)

1.3. Carbohydrate changes under water stress as related to root morphogenesis.
Nicole Vartanian (France)

1.4. Evolution des sucres solubles et de l'amidon au tours de l'assechement , puis de la rehumidification , chez les plantes plus ou moins resistantes A la secheresse (Carex et Gossypium) . Comparaison entre les parties aeriennes et souterraines.
Camille Hubac (France)

I.5. L'alimentation en oxygene des racines des plantes.
A. Pradet (France)

2. ROOT EXTENSION GROWTH AND REGENERATION

2.3. Root growth in seedlings of Acer saccharum
D. P. Webb and E. B-Drumbroff (Canada)

2.2. Rythmes de croissance et de ramification des systames racinaires de jeunes cadres in situ at en chambre cIimatisee
A. Riedacker (France)

2.3. Root regeneration potential in Douglas-Fir seedlings. Effect of photoperiod and air temperature on its evaluation and control.
Barbara E. Thompson and R. Timmis (USA)

2.4. Etude comparie in situ des parties aeriennes at des racines de peupliers (Ponulus X euramericana, cv 1214), issu de bouture cultivie daps les conditions climaciques 4. Grenoble
Janine Gagnaire-Michard, J. Jourdan, R. Plebin (France)

2.5. Effect of air and soil temperatures on root regeneration of tropical Pine seedlings. Sheikh Ali Abod (Malaysia)

2.6. Root growth in the GUELPH Rhizotron
R. J. Hilton **(Eadade)**

3. RQQT MORPHOGENESIS AND ARCHITECTURE OF ROOT SYSTEMS

3. I. Perception of gravity and georeaction
G. Perbal (France)

3.2. Renewal of the root cap of Cissus SycoIdes
Madame Sambin, Madame Rougier
P. Zandonella (France)

3.3. Response of Pine roots to growth substances
E. Hacskaylo (USA)

3.4. Culture de racines isalees de Pinus pinaster. Etude des racines dichotomes
Monique Faye, A. David (France)

3.5. Seasonal dynamics of fine roots in mature stands of Douglas-Fir of different water regimes. A preliminary report.
D. Santaatonic (USA)

3.6. Effect of water stress on flaw root growth
Yvette Menoux (France)

3.7. The case of the thickening root
D. C. F. Fayle (Canada)

3.8. Influence des cotyledons sur la croissance et le developpement du systAme racinaire du chine padoncul4 (Q. Robur L.)
M. Lamond (France)

3.9. Architecture et dynamique spatiale racinaires. F'. Kahn (France)

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3. LO. Comparison of the mOrphology of Fagus orientalis Lips KY and Loralta colurna L. root system in situ
Madame L. Liapova (Bulgaria)

3.11. Effect of light intensity on root growth of some forest seedlings I. Palashev (Bulgaria)

3.12. Breathing roots in a temperature tree, Salix pentandra L.
J. Jenik (Tchecoslovaquie)

3.13. Evaluation des consequences des deformations racinaires chez le pin maritime
A. Franclet (France)

3.14. Etude sur les conteneurs a patois rigides
J. M. Marien, G. Drouin (France)

3.15. Anti coiling container A. Riedacker (France)

3.16. Multiplication vegetative de merisiers ages par boutures de racines. Morphogendse du systeme racinaire de boutures de. noyers hybrides D. Cornu (France)

4. MINERAL AND WATER NUTRITION

4.1. Role de l'enracinement dans la nutrition des cultures
C. Maertens, M. Bosc (France)

4.2. Root phosphorus metabolism and V. A. Endomy-corrhiza.
Mme V. Gianinazzi-Pearson, S. Gianinazzi (France)

4.3. Absorption of ammonium and nitrate by mycorrhizal and mycorrhizal roots of Pine
R. C. France, C. P. P. Reid (USA)

4.4. Activite nitroganase potentielle des nodules d'Alnus jlutinosa; d'Alnus incana at d'Alnus cordate: modalitis des variations saisonnidres et cow paraison entre especes
G. Pizelle (France)

4.5. Etude de la dynamique de l'azote a haute altitude. Fixation par l'Alnus viridis,chaix, at etude ultrastructurale des nodules A. Moiroud, A. Capellano (France)

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Sandra A. Wilson, D. Atkinson (UK)

4.7. Influence de l'engorgement sur l'alimentation mine¯rale at hydrique de jeunes plants d'Epicea.
G. Levy (France)

4.8. Mycorrhisa and water stress
C. P. P. Reid (USA)

4.9. Water transport through mycelial strands to ecto mycorrhizal roots of Pine D. J. Read, A. Malibari (UK)

5. MYCORRHIZATION AND SEEDLING GROWTH

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H. E. Wilcox (USA)

5.2. Influence of fertilization and endomycorrhizal on growth of Acer pseudo-platanus. F. Le Tenon, J. Garbaye, A. Kabre (France)

5.3. Influence de la mycorrhization sur la croissance de jeunes plants forestiers (Pinus Halepensis Mill)
B. Kadic (Algerie)

5.4.0bservations sur les endomycorrhizes dans Vitis et leur caracterisation morphologique. P. Bonfante Fasolo, A. Fontana, I. Eynard (Italie)

5.5. Effect of I. A. A. on endomycorrhization
G. Azcon, G. De Aguilar, J. M. Barea
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5.6. Inoculation ectomycorrhizienne pour le reboisement en altitude
L. Froidevaux, R. Amiet (Suisse)

5.7. Influence de la concentration en phosphate (H_2PO_4) de la solution nutritive sur La mycorrhization du Pinus pinascer par Le Pisolithus tinctorius et l'Hebeloma cylindrosporum (elevage en caisson à aerosol nucritif) D. Mousain, M. Lamond(France)

5.8. TQuantificationt of mycorrhizal infection in Ericaceal.
K. Aaselwandier (Autriche)

6.0BSERVATIONS TECHNIQUES

6. I. Dispositif de culture de plantes entieres sur caisson a aerosol nutritif
M. Lamond, D. Mousain (France)

6.2. Minirhizotrons. A. Riedacker (France)

6.3. A comparison of a number of methods of determining root activity in fruit trees. D. Atkinson, H. P. Gurung (UK)

6.4. Root observation technique including soil moisture measurement
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WARRINGTON I. J. EDGE E. A. And GREEN L. M. Plant growth under hight radiant energy fluxes. Ann. Bot. 1978, 42, 1305-1313.

WILLIAMS W. M. and HOGLUND T. H. Temperature responses of New Zealand, spanish and New Zealand x Spanisk white clover populations. N. Z. J. Agric. Res. 1978, 21, 491-497.

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XXI. COMING EVENTS, MEETING AND EXHIBITIONS
REUNIONS ET EXPOSITIONS ANNONCEES

1979 July 3-5 Budapest (Hungary)

lInd ISHS symposium on small fruit virus diseases
Inf. Organ. Comm. Plant Protection and Agrochemistry Centre Pf 127
1502 Budapest (Hungary)

1979 July 3-11 Budapest (Hungary)

XIth ISHS symposium on Fruit Tree virus disease
Inf. Dr. M. NEMETH. Plant Protection Centre. Pt 127 1502 Budapest (Hungary)

1979 8-12 July Hannover (F. R. Germany)

XIV International Conference on basic and applied Chronobiology
Inf. ISC XIV Conference. Hedizinische Hochschule Dept Anacomie D 3000
Hannover 61 Karl Wiechert Allee 9 W. Germany

1979 July 8-13 East Lansing USA

9th International Congress on Rural Engineering
Inf. Prof. C. M. HANSEN CIRG Congress Coordinators 113 B Agricultural
Engineering Bldg Michigan St Univ. East Lansing Mich. 48824 USA

1979; July 11-21 Edimburgh Scotland (UK)

Nato Advanced Studies Institutes 79/5. Genome organisation and expression in plants
Inf. Dr. C. J. LEAVER Dept of Botany, King's Bldg, Mayfield Road Edimburg E 89 3JH Scotland (UK)

1979 12-16 juillet Doue la Fontaine (France)

Exposition a la gloire de la rose
Inf. 0. Charles Saintoin 97 Bd Malesherbes , 75008 Paris (France)

1979 July 16-22 Budapest (Hungary)

IInd Symposium on Spices and medicinal plants
Inf. Dr. P. TETENYI ,Plant Res. Inst. PF 11 -a 2011, Budakalasz (Hungary)

1979 August Leuven (Belgium)

ISHS Symposium on Witloof
Inf. Prof. C. Van ASSCHE Kard Mercierlaan 92, 3000 Heveriee (Belgium)

1979 August Aarslev (Denmark)

Symposium on Production planning in glasshouse floriculture

Info: Dr. V. A. Hallig Glasshouse Crops Research. Station Kirstinebjergvei 10, DK 3792 Aarsiev Denmark

1979 August 20- September 2. Island of Spetsar (Greece)

Nato Advanced Studies Institutes 79/59. Nucleic Acid Protein Recognition.
Inf. Dr. M. BUCKINGRAM. Inst. De Biologie Mol4culaire Inst. Pasteur, 25 rue du Docteur Roux, 75o15 *Paris* (France)

1979 August 20-september 5. Khabarovsk (USSR)

XIV Congress of Pacific Sciences

Info: Organizing Com. 49 Vavilov Str. V333 Moscow 117333 (USSR)

1979 August 27-31 Amsterdam (Netherlands)

Ilnd International syoposium on the role of water into urban ecology

Info: M. K. PLAXION PO Box 330 Amsterdam (Pays Bas)

1979 August 27-31. Dublin (Ireland)

Horticultural Educational Association (HEA): *Irish* Contributions to Horticultural Technology
Inf. Mr. DOUGLAS, Seven Piers, Rock Road, Blackrock Co. Louth (Ireland)

1979 August 27-september 1 , Geisenheim (FRG)

Symposium on breeding and processing of asparagus
Inf. Dr. H. D. HARTMAN , Inst. Gartenbau Postfach 1180, 6222 Geisenheim (5RD)

1979 August-September Angers (France)

Fruit tree breeding symposium
Inf . J. HUET , Station de Recherches d'Arboriculture Fruitiere BP 2011 Beaucouzee 49000 Angers (France)

1979 Automne Versailles (France)

Culture in vivo applications pour l'amalioration des plantes
Inf. M. C. DORE , INRA , Station d'Amelioration des plantes, 78000 Versailles (France)

1979 Septembre 2-5 Besancon (France)

Florexpo. Salon Europeen de Fournitures pour fleuristas
Inf. Florexpo, 33 rue du Pont Neuf, 75001 Paris (France)

1979 September 3-8 Leuven (Belgium)

VIth ISHS International Symposium on Horticultural Economics
Inf. Dr. U. AVERMAETE, 85 Sneppenstraat 3200 Kessello(Belgium)

1979 September 4-6 Kecskemet (Hungary)

6th Congress on Horticultural Mechanization
Inf. Scientific Society for Mechanical_ Engineers 1372 Budapest 5, POE 451 (Hungary)

1979 4-7 septembre ?ar'.. A (Trance)

Stage Technique ACTA:du ?rabid:re au protocole, des rdsultats aux decisions (journee prdparatoire le 20 mars 1979)

Inf. ACTA 149, rue de Bercy 75579 Paris Cedex 12 France.

1979 September 8-10 Padova (Italy)

FLORMART-Flortecnica - Hobbyflora
Inf. Fiere di Padova, via Tommaseo 59, 35100 PADOVA (Italie)

1979 September 9-14 Shefayim (Israel)

VIIIth International Congress of Biometecrology

Info: Israel organizing Committee. ISB Congress. c/o Israel Meteorological Society PO Box 25 Bet Dagen Israel.

1979 September 10-12 Wageningen (The Netherlands)

ISHS Working party on Internal transport sustems for maximizing the labour efficiency of greenhouses
Inf. C. J. Van der POST, EMAG PO Box 43 Wageningen (The Netherlands)

1979 10-i4 september EVORA (Portugal)

ISHS Symposium on production of tomatoes for processing

Info: Associacao Portuguese de horticultura. Universidade de Evora Apartado 94 Evora. Portugal

1979 10-28 septembre Paris (France)

Cycle de Formation continue: Microbiologie du sol et des eaux

inf.: ADEPRINA , Mme EWALD 16 rue Claude Bernard, 75231 Paris Cedex 05

1979 11-14 septembre Littlehampton (UK)

ISHS-IWOSC Symposium on Research on recirculating Water culture. Nutrient film technique

Info; Dr. R. G. HURD G. C. R. I. Littlehampton W Sussex BN 16 3PU United

Kingdom 197914-17 septembre LYON (France)

Hormatec 79 Salon des Techniques hortico maraicheres
Plantexpo: Biennale Horticole Fran;aise
Inf. Hormatec 79, Foire internationale de Lyon, Palais des Congr4s, 69459 Lyon Cedex 3 (France)

1979 September 17-19 Kuala Lumpur (Malaysia)

Second International Sago symposium (Energy plantations for equatorial conditions, Harvesting and processing technology, Industrial and domestic applications for the components)
Inf. Petaling PO Box 46, Old Kiang Road, Kuala Lumpur (Malaysia)

1979 September 17-20 Auchincruive Scotland (UK)

ISHS-LSOSC Symposium on Substrates in Horticulture other than soils in situ
Inf. G. C. S. WILSON, Chemistry Dept The Wesc of Scotland Agricultural College Auchincruive, Ayrshire Scotland (UK)

1979 September 17-21 Manila (Philippines)

Symposium of International Society for Tropical Root Crops
Inf. Dr. M. R. VILLANUEVA Training Centre, Visayas State college of agriculture Baybay Leyte 7127(Phillipines)

1979 September 18-20 Wageningen (The Netherlands)

Working party ISHS on Internal transport sustems for maximizing the labour efficiency of greenhouses
Inf. C. J. Van der Post. IMAG POB 43 Wageningen (The Netherlands)

1979 Septembre 23-25 Lille (France)

2e salon professionnel pour Fleuristes, Grainetiers, horticulteurs. Eurofleurs 79
inf. Promotion Industrielle et Commerciale SARL 58 Av. Robert Schuman 59370 Mons en Bareuil (France)

1979 september 24-26 Los Banos Cebu City (Phillipines)

ISHS Symposium on Current problems in fruit and vegetables crop research
Inf. Dr. E. B. PAUTASTICO, coll. Of Agriculture, Los Banos Laguna (Philippines)

1979 25-27 septembre Nimes (France)

Formation permanence :Cultures maraicheres sur substrat hors sol
Inf. CTIFL Invuflec, 22 rue Bergere, 75009 Paris

1979 25-28 septembre Paris (France)

Salon International de Motoculture de Plaisance jardinage
Inf. SIMA 24 rue du Pont, 92522 Neuilly sur Seine Cedex (France)

1979 September 25-29 Varna Bulgaria

Ist International Symposium on plant nutrition
Inf. A. P. PAVLOVA, M. Popov Institute of Plant Physiology Bulgarian Ac. Sc. Sofia 1113, G. Bontchev str. Block 6 (Bulgarie)

1979 26-29 septembre Paris (France)

Salon professionnel international de quincaillerie , jardinage, entretien bricolage, menage; Quojem
Inf. Quojem, 42, rue du Louvre, 75001 Paris (France)

1979 Octobre Paris (France)

3e congres mondial de l'Union Internationale des Ingenieurs Forestiers
Inf. J. FROMENT, 8 Parvis St Henri, 1200 Bruxelles (Belgique)

1979 October Wageningen (The Netherlands)

Meeting on breeding of Cruciferee
Inf. R. TOXOPEUS, SVP PO Box 117 Jageningen, (Neth).

1979 2-5 octobre Boigneville (France)

Stage technique ACTA:Experimentation planifiee
Inf. ACTA 149, rue de Bercy 75579 ?aris Cedex 12 (France)

1979 Octobre 7-10 Birmingham (UK)

Exposition internationale pour les loisirs et le jardin (G. LEE)
Inf. Inter Garden Promotions Ltd, Columbia House, 69 Aldroych London WC 2CB4 DY (UK)

1979 October 10-13 Mainz (FRG)

European Weed Research Society (EWRS) symposium on the influence of different factors on the development and control of weeds

Inf. Dr. M. HANF, Postfach 220, Limburgerhof (FRG)

1979 15-21 october Belgrade Zemun (YugosLovia)

Xth Annual Meeting of ESNA
Inf. ESNA, Secretariat P0B48 -6700 AA Wageningen (The Netherlands)

1979 October 22-december 20 Bet Dagan (Israel)

XI International Course on irrigation (Water ressources for irragation. Soil management . Soil water plant relationship. Agrometeorology. Water suitability for irrigation. Irrigation technology. Crop water requirements. Water economics. Sources of information on irrigation).
Inf. Dr. K. M. SCHALLINGER The Volcani International Courses PO BOX 6
Bet Dagan (Israel)

1979 October 24-26 Nice (France)

International Congress: the utilization of solar heat in industry and agriculture
Inf. Girard MOREL, 24 Bd Stalingrad, F 06300 Nice (France)

1979 25-29 octobre Paris (France)

Equip'mag: salon international de l'equipertent des commerces at metiers
Inf. Equip'mag 42 rue du Louvre 75001 Paris (France)

1979 6-9 novembre Grenoble (France)

Seminaire du groupe d'etude des racines: "Les correlations entre les racines at les parties airiennes
Inf. Madame J. Gagnaire-Michard, Biologie vegetale D. R. F. CEN Grenoble 85 X 38041 Grenoble Cedex (France)

1979 november 7-9 Holiday Inn Los Angeles Ca (USA)

International Symposium on trace Element stress in plants: Effects and methodology
Inf. Dr. Wallace or Dr. Berry , Laboratory of Nuclear Medicine and Radiation Biology Univ. Of California Los Angeles, 900 Veteran Avenue L. A. Ca 90024 (USA)

1979 7-11 novembre Valencia (Spain)

Iberflora 79
Inf. Iberflora , Apartado de Correos 13, Valencia Espagne

1979 November 10-17 Mazatlan, Sinaloa (Mexico)

27th Annual Congress of ASHS-Tropical Region
Inf. Dr. Guillermo Hernandez Bravo INIA-SARH Apartado Postales 6, 882-y-6-883 Mexico 6 D. F.

1979 13-16 novembre Grignon (France)

Cycle de formation continue: Proteines foliaires at alimentation

Inf.: ADEPRINA, Mme EWALD, 16 rue Claude Bernard, 75231 Paris Cedex 05

1979 26-30 november Sydney (Australia)

VIIth Conference of the Asian Pacific Weed Science Society (APT1ISS)

Info: The Secretary PO Box 287 Haymarket NSW 2001 Australia

1979 27-28 novembre Paris (France)

Cycle de formation continue: Examen des problames lies aux aspects d'epidermiologie des plaices

Inf.: ADEPRINA, Mme EWALD, 16 rue Claude Bernard, 75231 Paris Ceder. 05

1979 10-14 decembre Grignon (France)
Cycle supirieur d'Agronomie: encluSte ou experimentation ? Leur valeur respec-• tive pour 1 etude des orobl&mes agricoles

Inf.: ADEPRINA, Mme EWALD, 16 rue Claude Bernard, 75231 Paris Cedex 05

1979 December 16-20 Tel Aviv (Israel)

5e Congres mondial des ingenieurs et architectes. Dialogue sur le developpement objectif 21e siecle
Inf. Secretariat Chambres des Ingenieurs Conseils de Belgique Hotel Ravensteiu, Rue Ravenstein 3, 1000 Bruxelles (Belgique)

1980 Alexandria (Egypt)

ISHS seminar on Tropical and subtropical Horticulture
Inf. Zidan Abdel-Al. Coll. Of Agriculture Univ. Of Alexandria. Alexandria (Egypt)

1980 Littlehampton (UK)

Eucarpia Working Group on leafy vegetables
Inf. J. W. Maxon Smith, Glasshouse Crops Research Institute Littlehampton (UK)

1980 Wageningen (Netherlands)

ISHS symposium on Postharvest handling of vegetables
Inf. W. S. Duvekot, Sprenger Inst. Haasteeg 6
Wageningen

1980 January (Israel)

Symposium on (rootstocks) fruit quality and yield improvement in 'Mediterranean citrus

Info: Dr. S. P. Monselise Dept. Of Horticulture ?0B 12 Rehovot

(Israel) 19806 months. Exposition rationale horticole Bale (Suisse)

1980 Poland

ISHS Symposium on Nutrition and fertilization
Inf. Dr. O. Nowosielski, Vegetable Dept Res. Inst.96-100 Skierniewice (Poland)

1980 Italy

ISHS Symposium on Vegetable seed production
Inf. Dr. M. GAVRAS School of Biological Sc. Univ. Of BATH BATH BA2 7AY (UK)

1980 or 1981 (UK ?)

ISHS Symposium in timing field production of vegetables
Inf. Dr. D. GRAY Nat. Vegetable Res. Sta. Wellesbourne, Warwick CY 35 9 EF(UK)

1980 or 1981 Nigeria

VIth Africain Horticultural symposium on indigenous vegetables Inf. Prof. H. D. TINDALL, Nat. Coll. Of Agric. Engin. Silsoe Bedford MK45 4DT (UK)

1980 February 12-15 Brussels (Belgium)

50th anniversary Meeting commission Intercontinentale du Genie rural: Evolution of Research in Agricultural Engineering
Inf. P. F. Y. ABEELS, Dept. Genie Rural, Univ. Louvain La Neuve Place Croix du Sud, 3, 8-1348 Louvain La Neuve (Belgique)

1980 March 2-6 Charleston (South Calif USA)

Xlth annual conference of Environmental design Research association:
Optimizing Environments: Research, Practice and Policy
Inf. Stephanie SANDERS, Center of Metropolitan Affairs. College of Charleston South California 29401(USA)

1980 Printemps Montpellier (France)

Seminaire sur "les echanges entre les racines at le sot
Inf. Mr. LOSSAINT CEPE Rte de Mende, BP 1018 34000 Montpellier (France)

1980 Avril Gand Belgique

Floralies Gantoises

1980 April 9-11 Canterbury Kent (UK)

Eucarpia IOBC Meeting on Breeding for resistance to insects and mites
Inf. Miss J. R. PARKER, East Mailing Research Station Maidstone Kent ME 19
6 BJ (UK)

1980 April to June Wageningen (The Netherlands)

International Agricultural centre (IAC) Course on seed technology in the Netherlands
Ini. Dr. R. JONKERS, Wageningen (The Netherlands)

1980 May 5-9 Funen (Denmark)

3rd LSHS Symposium on Flower bulbs
Inf. M. E-RASMUSSEN, State Expc. Horticulture Station Kirstinebjergvej 6 Aarslev DK5792 (Denmark)

1980 May 17-september 2 Montreal (Canada)

Florales internationales de Montreal
Inf. Floralies internationales du Quebec H 2Y 1 P5cCanada)

1980 May 18-24 Wageningen (The Netherlands)

Fifth International Congress on Soilles Culture (ISOSC) Inf. Dr. A. A. STELNER PO Box 52, 6700 AB, Wageningen (The Netherlands)

1980 May 18-23 Bad Rarzburg (FRG)

Fifth ISHS Symposium on virus diseases of ornamental plants
Inf. Dr. R. KOENING Inst. Fur Virusserologie Messeweg 11/12-33 Baunschweig (BRD)

1980 June 29-July 5 Urbino (Italy)

First Eyropean Bioenergetics Conference
Inf. Prof. A. Baccarini Melandri, Instituto Botanico Via Irnerio 42 40126 Bologna (Italy)

1980 July 6-13 Vancouver (Canada)

ISHS symposium on Rubus
Inf. R. A. DAUBENY, Agriculture Canada, Vancouver Research Station 6660 N W. Marine Drive, Vancouver BC V6T IX2 (Canada)

1980 July 20-25 Strasbourg (France)

8th International Congress on Photobiology
Info. M. CHARLIER Centre de Biophysique Moleculaire IA Av. De la Recherche Scientifique 45045 Orlaans Cedex France

1980 July 22-29 Brisbane (Australia)

V International Symposium on Biological Control of Weeds
Inf. Dr. K. L. S. HARLEY, CSIRO, Entomology Private Bag 3 Indooroopilly Queensland 4068 (Australia)

1980 August Bolzano (Italy}

ISHS symposium on Hight density planting
Inf. Dr. H. Oberdorfer, Sud Tirol, Beratungsung f. Obst and Weinbau, Andreas Hoferstr. 9, F 3911 Lana (Italy)

1980 August Davis Calif (USA)

IInd Inst. Symposium on Post harvest physiology of cut flowers

Info: Prof. A. M. KOFRANEK Dept of Environmental Horticulture Univ. Of California Davis CA 95616 (USA)

1980 August Merano (Italy)

ISHS Symposium Research and development on orchard and plantation systems
Int. Dr. S. J. WERTHEIM Research Station for fruit Growing Brugstraat 4475 AN Wilhelminadorp,(The Netherlands)

1980 September Brasilia (Brasil)

ISHS Symposium on Vegetable Crop research
Inf. L. Montoya IICA Caixa postal 16 074 2C 01 2000 Rio de Janeiro (Brasil)

1980 september Wageningen (The Netherlands)

ISHS Symposium on Vegetable storage
Inf. Ir W. S. DUVEKOT, Sprenger Inst. Haagsteeg 6, Wageningen (The Netherlands)

1980 September BRUNSWICK (F. R. Germany)

5th symposium on virus diseases of ornamental plants
Inf. Dr. Koening, Inst. Virusserologie, Messeweg 11/12, 33 Braunschweig B R D (Germany)

1970 September Budapest (Hungary)

11th Symposium on Fruit tree virus diseases
Inf. Dr. H. Ronde, Kristensen, The State Plant Pathology Institute Lottenborgvej 2, 2800 Lyngby (Denmark)

1980 September 7-12 Dublin (Ireland)

ISHS Symposium More profitable use of energy in protected cultivation
Inf. Dr. T. M. O'FLAHERTY Agric. Inst. Malahide Road Kinsealy Research Centre Dublin 5 (Ireland)

1980 October 6-L1 (probably) Lisboa (Portugal)

8th International Agricultural Plastics Congress
Inf. A P P A rue de D. Estefania , 32, 2e Esq. Lisboa (Portugal)

1981 Versailles (France)

ISMS Symposium on Protected cultivation of chrysanthemum (propagation, flower physiology, nutrition)
Inf. Prof. P. Lemattre, Ecole Nat. Sup. Horticulture, 4 rue Hardy 78000 Versailles (France)

1981 Switzerland or Finland

ISHS Symposium on the use of artificial light in horticulture

Info: ISHS Commission for protected cultivation. Box 1011 Aalsmeer The Netherlands

1981 or 1982 Aarslev (Denmark)

ISHS Symposium on Production planning in glasshouse floriculture
Inf. Dr. V. A. Hallig, Glasshouse Crops Res. Sta. Kirstinebjergnj 10, DK 5792 Aarslev (Denmark)

1981 Netherlands

ISHS Symposium on water supply and irrigation
Inf. Prof. J. F. Bierhuizen Dept of Hortic. Agric. University PO Box 30 6700 AA Wageningen (Netherlands)

1981 (Rumania)

ISHS Symposium on Apricot culture and decline
Inf. Dr. S. A. Paunovic, Fruit Res. Inst.32000 Cacak (Yugoslavia)

1981 or 1982 May San Diego California (USA)

ISHS Symposium on Protected cultivation of carnations
Inf. S. T. Besemer, 3883 Ashford Street San Diego CA 92111 (USA)

1981 Avril GAnes (Italie)

EUROFLORA

1981 July-August Aarslev(Denmark)

ISHS Symposium on timing of field production of vegetables
Inf. B. Jorgensen and J. Jensen,Stateus Forsogstation D 5792 Aarslev (Denmark)

1981 21-28 august Sydney (Australia)

XIII International Botanical Congress
Inf. Dr. L. EVANS, CSIRO PO Box 1600 Canberra City ACT 2601 (Australia)

1981 November 9-13 Japan Tokyo

International Citrus Congress (ISC)
Inf. International Citrus Congress. Okitsu Branch Fruit Tree Research Station Shimizu 424 02 Shizuoka !Japan)

1982 22-27 August Conventry (UK)

The 9th International Colloquium on plant Nutrition (formely Plant Analysis)
Inf. Dr. R. J. Greenwood, National Vegetable Research Station Wellesbourne, Warwick C V 35 9 Er (UK)

1982 6 months Floriades des Pays-Bas

1982 29 august- 4 september Hamburg (FRG)

XXI st International Horticultural Congress

Info; The Secretariat Hamburg Congress Centre POB 302360 D 2000. Hambourg 36 F. R. Germany

1982 or 1983 August Aarslev (Denmark)

Production planning of Glasshouse floriculture (ISHS)

Info: V. A. Eallig Research Institute for Glasshouse Crops Kirstinebiergvej 10, DK 5792, Aarslev, Denmark

1983 6 months IGA A Hambourg (FRG)

1984 6 months WIG, Vienne (Autriche)

1985 Avril Floralies zantoises (Belgique)

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Nous remercions 5 l'avance, sous caux Tai nous enverront des informations ou articles que nous reproduirons, si possible, dans les prochains numiros.

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