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PHYTOTRONIC NEWSLETTER N°11

Contents

I - EDITORIAL

Here is our third issue for the year 1975. From now on, we hope without difficulty, to continue publishing three issues per year, thanks mainly to the information that you forward to us and the encouragement that you send to us.

Once again we thank all those who have sent financial aid, whether personal or through official or private organizations. As always we request that you address your donations to our intermediary by writing your checks or money orders in the name of :

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with the endorsement : "Participation aux frais de parution du Bulletin Phytotronic Newsletter".

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The subjects dealt with in this issue are less polyvalent, perhaps, than in preceding issues, yet they bring us news of a purely phytotronic nature certain to interest our readers.

Under the heading "Symposium" we have reproduced the title of papers presented at the First International Congress of Ecology in The Hague in September 1974 as well as a report edited by Dr. Y. BOYER on the First Meeting of the International Association of Plant Physiology in Wurzburg in September 1974. Both of these scientific meetings stand as reminders that one of our essential preoccupations is research, particularly that of plant physiology.

Next we come to the heading "Research Strategy".

Although mostly descriptive, we hope that the subjects under consideration will interest numerous readers. The first report, from material sent by Professor H. HELLMERS (1973 and 1974 Annual Reports), gives information on the life and work of the scientific complex SEPEL in the United States, the Southeastern Plant Environment Laboratories. The second report sent by Dr. P. S. HAMMES describes the research and the Phytotron at the Experimental Station at the University of Pretoria (South Africa). Finally, the third one, sent by Mr. Stein NILSEN, describes the Phytotron at the University of Oslo (Norway).

Under the heading "Technique", which is the most important in this issue, we cover varied phytotronic domains. Five reports relate the possibilities for work in certain special cases, and they are :

- the report sent by Dr. G. H. A. RYLE et al. , of Great Britain : Experimental research in controlled environments in relation to the perennial grass crop.
- the problem of Root temperature control in Phytotrons, a report edited by G. I. MOSS and E. S. TRICKETT of Australia.

- Use of growth rooms in Cassava Research, a report edited by L.A. HUNT et al. , of Canada.
- Use of controlled-environment facilities as an adjunct to field research on potentially tropic-adapted grain legumes, a report edited by R. J. SUMMERFIELD et al. , of Great Britain.
- Soil Moisture control for phytotronic studies, a report edited by Dr. L. Art SPOMER, USA,

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To conclude this editorial we draw our readers' attention to the geographical dispersion of the various reports published which underlines, if it is necessary to do so, the international merit of our Bulletin.

We do have one considerable regret, expressed by many of those who write to us, concerning the lack of contacts, information or news coming from the socialist countries, the USSR and the Popular Democracies as a whole. We invite our correspondents from these countries to send us reports which we will gladly publish to satisfy the wishes of many readers.

We thank you all in advance.

P. CHOUARD, R. JACQUES and N. de BILDERLING

II - FIRST INTERNATIONAL CONGRESS OF ECOLOGY
The Hague, The Netherlands - September 8-14 1.974

The proceedings of this Congress were kindly given to us by one of the participants and they attest to its importance and the large variety of subjects discussed. Readers who desire more information should write to : International Association for Ecology (INTECOL). Mr. R. LANIER. Laboratory of Limnology, University of Wisconsin, Madison - Wisc. 53706 (USA).

We know that many of our readers are interested by problems of ecology and especially plant ecology ; for them we give the following titles of the all papers. Full texts and summaries of the discussions during the congress are published in a separate book : "Unifying Concepts in Ecology" (W. H. van DOBBEN and G. R. GRADWELL Ed.) 197 5 ; Dr. W. JUNK Publishers, The Hague, Pudoc, Wageningen (The Netherlands), 250 pp.

Titles of papers presented at the congress :

Presidential address : A. D. HASLER (USA), "Unification of Land water ecological systems".

Theme 1. Flow of energy and matter between trophic levels.

1. Introduction to theme 1. F, B. RIGLER (Canada).
2, Principles of energy and material exchange in ecosystems. D. E. REICHLE, R. V. O'NEILL, H. H. SHUGART, W. F. HARRIS (USA).
3. Generation and utilization of ATP in chemoorganotrophic bacteria. H. VELDKAMP (The Netherlands).
4. Flow of energy and matter between trophic levels (with special reference to higher levels). S. S. SCHWARTZ (USSR).
5. The physical foundations of global ecological processes. H. J. MOROWITZ (USA).
6. Models describing energy flow and nutrient cycles in ecosystems. P. DIAMOND (Australia).
7. Energy flow relationships in a shortgrass prairie ecosystem. R. ANDREWS, D. C. COLEMAN, J. E. ELLIS and J. S. SINGH (USA),
8. On the regularities of matter and energy transport in the trophic levels of the marine communities. T. S. PETIPA (USSR).

Theme 2. Comparative productivity in ecosystems.

I. Comparative productivity in ecosystems. The primary productivity, H. LIETH (USA).
2. Comparative productivity in ecosystems. Secondary productivity. 0, W. REAL (U. K.) and S. F. Mac LEAN (USA).
3. Energy and matter economy in ecosystems. L. RYSZKOWSKI (Poland).
4. Factors involved in dynamics of algal blooms in Nature. M. SHILO (Israel).
5. Comparative productivity of terrestrial ecosystems in Japan, with emphasis on the comparison between natural and agricultural systems, J. IWAKI (Japan).

6. Dynamics of net primary productivity of grazing land and forest ecosystems in western India. S. C. PANDEYA (India).
7. Carbon balance and productivity of two cool desert communities dominated by shrubs possessing C3 and C4 photosynthesis. M.M. CALDWELL (USA).
8. Life form survival strategy and CO2 exchange. F. E. ECKARDT (France).
9. Community productivity and optimum exploitation of biological resources. V. E. ZAIKA (USSR).

Theme 3. Diversity, stability and maturity in natural ecosystems.

1. Diversity, stability and maturity in natural ecosystems. G. H. ORIANS (USA).
2. Diversity, stability and maturity in natural ecosystems. R. MARGALEF (Spain).
3. Stability on ecosystems : some comments. R.M.MAY (USA).
4. Stability in plant communities. R. H. WHITTAKER (USA).
5. Structural analysis of aquatic communities. S.R. KERR (Canada).
6. The validity of the diversity stability hypothesis. D. GOODMAN (USA).
7. Structural and functional responses on oyster reef community to a natural and severe reduction in salinity. P. F. LARSEN (USA).
8. The overgrazing cycle as a characteristic of tropical savannas and grasslands in Africa. G. A. PETRIDES (USA).

Theme 4. Diversity, stability and maturity in ecosystems influenced by human activities.

1. Diversity, stability and maturity on ecosystems influenced by human activities. J. JACOBS (Germany).
2. Response of natural microbial communities to human activities. M. ALEXANDER (USA).
3. Structural and functional properties as they influence ecosystem stability. F. B. GOLLEY (USA).
4. Relations between diversity and stability in experimental plant systems. P. JACQUARD, P. POISSONET (France) ; P. DONADIEU (Maroc) ; A. TROUVAT, A. GALLAIS (France).
5. Diversity, stability and response to human disturbance in estuarine ecosystems. D. F. BOESCH (USA).
6. The stability of Canadian boreal forest ecosystems. G. F. WEETMAN (Canada).

Theme 5. Strategies for management of natural and man made ecosystems.

1. Strategies for management of natural and manmade ecosystems. J. D. OVINGTON (Australia).
2. Fail-safe or safe failure ? C. S. HOLLING (Austria).
3. Management strategies in some problematic tropical fisheries. W. H. L. ALLSOPP (Canada).
4. Man -Made natural ecosystems in environmental management and planning. E. van der MAAREL (The Netherlands).
5. Ecological considerations in the management of semi-arid ecosystems in south Central Africa. B. H. WALKER (Rhodesia).

6. Regional environmental systems analysis : an approach for management. M. M. McCAR THY, R. C. DURFEE, M. L. NEWMAN, S. L. YAFFEE, R. BETSON, C. W. CRAVEN, T. L. COX, J. HOLBROOK, D. D. HUFF and R. STRAND (USA).
7. Development of strategies for management of marine and estuarine sanctuaries in the United States of America. M. P. LYNCH (USA).
8. Ecological land survey, the bio-physical basis of land use planning, the Saguenay-lac, Saing-Jean region, Quebec. M. JURDANT, V. GERARDIN and J. L. BELAIR (Canada),
9. Management of man made forest ecosystems with special reference to the current situation in Japan and prospects for the future. T. SATOO (Japan).
10. Formation of ecosystems in the regulated plain rivers and feasibility of their control. A. V. TOPACHEV SKY, Y. Y. ZEEB, L. A. SIRENKO (USSR).

1st Symposium IBP : Freshwater, brackish and marine ecosystems their similarities and differences at all trophic levels.

1. Primary production in the sea. J. J.WALSH (USA).
2. Primary production in freshwater. D. W. SCHINDLER and E. J. FEE (Canada).
3. Production in marine planktonic communities. R. J. CONOVER (Canada).
4. Secondary productivity in fresh waters - its values and efficiencies in plankton food chain. A. HILLBRICHT-ILKOWSKA (Poland).
5. Comparison of freshwater and marine systems : the direct and indirect effects of solar energy on primary and secondary production. K. H. MANN (Canada).

2nd Symposium IBP : Global geography of biological productivity.

1. Primary productivity of the main world ecosystems. L. E. RODIN, N. I. BAZILEVICH and N. N. ROZOV (USSR).
2. Energy flow and biogeochemical regularities of the main world ecosystems. N. I. BAZILEVICH (USSR).
3. The regularities of bacteria biomass reproduction in the soils of different geographical zones. T. V. ARISTOVSKAYA (USSR).
4. Productivity and carbon metabolism and broadleaved forests : a summary of progress from the International Biological Program. D. E. REICHLE, J. S. OLSON, R. V. O'NEILL and H. H. SHUGART (USA).

3rd Symposium IBP : The evolution of ecosystems and its contribution to biogeography and evolutionary theory.

1. Introduction. W. F. BLAIR (USA).
2. An evolutionary approach to the study of ecosystems. G. H. ORIANS (USA)
3. The origin and structure of American arid zone ecosystems. The producers : interactions between environment form and function. P. C. MILLER and H. A. MOONEY (USA).
4. Parallel and convergent evolution, and bird diversity, in Mediterranean habitats. M. L. CODY (USA).
5. Producer-consumer interactions. G. H. ORIANS, R. G. CATES, D. F. RHOADES and J. C. SCHULTZ (USA).

4th Symposium IBP : Stable and unstable ecosystems with man as an integral component in different climatic zones.

1, Stability in arid ecosystems and the effects of man on it. I. NOY MEIR (Israel).
2. Man and stability of some forest ecosystems. J. S. OLSON, M. F. OLSON and W, T. SWANK (USA.).

5th Symposium IBP : Prediction of ecosystems response to human intervention.

1. Predicting short and long term changes in the function and structure of temperate forest ecosystems. J. F. FRANKLIN and R. H. WARING (USA).
2. Management of ecosystems : information supplied by simulation models, D. A. JAMESON (USA),
3, Human impact on transportation and diversity in ecosystems. How far is extrapolation valid. R. MARGALEF (Spain).

1st Symposium of International Steering Committee (ISC) : critical evaluation of systems analysis and modelling in ecosystems research and management, Data collecting and processing for predictive purposes.

1. The hierarchical approach to model building. D. H. GOODALL (USA).
2. Evaluation of models. H. van KEULEN (The Netherlands).
3. Modelling by man machine conversation technique. T. URABE (Japan).
4. Future prospects of systems analysis in ecology. J. N. R. JEFFERS (ILK).

2nd Symposium ISC : Methods of experimentation with ecosystems in the laboratory results in terms of field conditions.

1. Systems identification : a theoretical method applied to tracer kinetics in aquatic microcosms. E. HALFON (USA).
2. Experiments to analyze the behavior of young spruce forest at different nutrient levels. C.O. TAMM (Sweden).

3rd Symposium ISC : Ecological interpretation of remote sensing data.

Remote sensing information systems in the service of biology. M. F. BAUMGARDNER (USA).
2. Aerial photography, remote sensing and ecology. I. S. ZONNEVELD (The Netherlands).
3. Interpretation of temporal data from ERTS-I demonstrating the brown and green wave. B. BLAIR (USA),
4. Multilevel ecological approach using remote sensing techniques. B. LACAZE and G,RIIVIBAULT (France).
5. Wheat stem rust warning using satellite imagery. S. NAGARAJAN (India).
6. Automatic decision classification of ecosystems and their pattern recognition in upwelling regions. K. H. SZEKIELDA (USA).
7. Remote sensing applied to the grassland biome. H. G. FISSER and J. C. SHAVER (USA).
8. How can ecology prepare itself for remote sensing. S. A. HEMPENIUS (The Netherlands).
9. Some results in earth and ocean physics. F. O. von BUN (USA).

4th Symposium ISC : Contribution of the study of parasitic systems to general ecology.

1. Contributions of biological control to understanding ecosystem dynamics. C. B. HUFFAKER (USA) and F. WILSON (U. K.).
2. Stabilizing mechanisms in soil microflora. B. SCHIPPERS (The Netherlands).
3, Population biology of parasites with special reference to the effect of ecosystem changes due to humour activity. C. R. KENNEDY (UK).
4. Mathematical models in the population ecology of parasites. D. J. BRADLEY (U. K.).
5. The ecology of onchocerciasis in relationship to the ecology of man. B. 0. L. DUKE (Cameroon).

5th Symposium ISC : Ecological consequences of deforestation for vegetation soil and aquatic systems mainly in the tropics.

1. Effects of forest clearing on the northern hardwood forest ecosystem and its biogeochemistry. G. E. LIKENS and F. M. BORMANN (USA).
2. Studies on the secondary succession of tropical lowlands : the life cycle of secondary species. A. GOMEZ-POMPA and L. VAZQUEZ-YANES (Mexico).
3. Succession studies in the humid tropical lowlands of Surinam. J. H. A. BOERBOOM (The Netherlands).
4. Inundation of a tropical forest in Surinam (Dutch Guiana), South America. P. LEENTVAAR (The Netherlands).
5. Information about the consequences of accelerated deforestation in Brazil. M. G. FERRI (Brazil).
6. The soil erosion problem in Java. 0. SOEMARWOTO (Indonesia).
7. Ecological effects of the regressive succession Muhulu-Miambo savannah in upper-Shaba (Zaire). R. FRESON, G. GOFFINET and F. MALAISSE (Zaire).

Special Symposium Ist : Seagrass ecosystems.

Dynamics of seagrass ecosystems. C. P. McROY and K. W. BRIDGES (USA)

Special Symposium IInd : Aspects of human ecology.

1. Human biology and the ecosystem concept. J. S. WEINER (U. K.)
2. Human ecological studies of circumpolar populations. F. A. MAIN (USA).

Special Symposium IIIrd : Optimization in ecological system.

1. Numbers of species and optimization in biology. G. INNIS (USA).
2. Modeling and management of ecosystems via optimal control theory. T. L. VINCENT, R. H. PULLIAM and L. G. EVERETT (USA).
3. Instantaneous (static) Vs long-term (dynamic) optimization in ecosystems. P. L. KATZ and M. W. BARTNICK (USA).
4. On the evolution of habitat selection. M. L. ROS ENZWEIG (USA).
5. A method for formulating suboptimal policies for crudely modeled ecosystems. B. S. GOH, T. L. VINCENT and D. J. WILSON (Australia).

Closing session : The significance of ecological principles for society.

1. Rural ecology in developments. 0. SOEMARWOTO (Indonesia).
2. The program on man and the biosphere (MAB). F. di CASTRI (Unesco - France).

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III - FIRST MEETING OF THE INTERNATIONAL ASSOCIATION OF PLANT PHYSIOLOGY (IAPP)

(Wurzburg, FRG - September 23-29 1974)

Report sent by Dr. Y. BOYER (INRA, route de Saint Cyr - 78000 Versailles France).

This Association, created in 1955, aims to promote the development of Plant Physiology at an international level. Its objective may be reached through cooperation to the organization of international congresses dealing with Plant Physiology, Plant Biochemistry and related disciplines, by organizing international Symposia on physiological subjects, by facilitating the publication of articles on Plant Physiology in specialized publications.

The President of the Association is currently Prof. H. G. BURSTROM of the University of Lund (Sweden) and the Secretary General is Prof. P. E. PILET of the University of Lausanne (Switzerland).

The first scientific meeting was held in Wurzburg (Federal Republic of Germany) from September 23 to 29 1974. The President of the Organizing Committee was Prof. W. SIMONIS of the University of Wurzburg.

The scientific program dealt with the two following themes :

I - Physiology and plant structure.

Section I - Membrane and wall relations, (organized by P. E. PILET, Switz.)

Origin and specificity of cell surface - chemical composition (lipid and protein) of membranes - cell wall structure and cell elongation - control of cell wall extensibility (auxin, pH).

Section II - Structure and function of chloroplasts. (organized by W. SIMONIS and W. URBACH, FRG).

Development and structural modifications of the photosynthetic apparatus - constituents of ribosome, phycobiliproteins and lamellae systems - chloroplast reactions to environment - localization and function of cytochrome and pigments.

Section III - Plants and gravity. (organized by A. SIEVERS, FRG).

Root geotropism - statoliths - statocytes - amyloplasts - geoperception - inhibitor and curvature.

Section IV - Structure and physiology of transport. (organized by W. SIMONIS, FRG).
Ultrastructure, cytochemistry, biochemistry and physiology of ion translocation. Regulation of ion transport.

II - Water supply and plant productivity.

(Organizers : 0. L. LANGE, L. KAPPEN and E. D. SCHULZE). See analysis below.

A synthesis of the papers presented during the Symposium devoted to the above theme is achieved here. The elements in this analysis can be gathered under two main headings :

Effects of drought on plant productivity.
. Modelization of productivity and water consumption.

1. - Study of the effects of drought on plant productivity.

. At the level of photosynthetic apparatus activity.

Global activity. Papers by :

- T. C. HSIAO, E. ACEVEDO, E. FERERES, D. W. HENDERSON, A. VEGA : "Parameters of growth, productivity and water consumption of maize under slight but prolonged water deficit".
. R. BORKAMM : "Water and organic matter production".
. B. R. STRAIN : "CO2 exchanges, balance between water and growth in the planting of Pinus taeda".
- G. P. HARRIS : "Productivity, physiology and water content of Lichen thallus".

The objective is to determine water efficiency : assimilation, transpiration, in natural growth conditions.

Measurements of net photosynthesis, of respiration in the dark, of water potential of tissues, of photosynthesizing surfaces, of assimilation transfers.

Techniques : notably aerodynamic regarding gas exchanges.

Plants studied : Maize, Pinus taeda, Quercus pubescens and Q. ilex, Lichens (for the latter the color of the thallus is an important factor of the energy balance).

Results : studies of relationships with climatic factors, the preponderant factors being : intensity of radiation (STRAIN) - surface temperatures (HARRIS) - rate of dehydration (BORNKAMM).

Biochemical activity : (CO2 fixation).

Plants in CAM (LUTTGE : "Flux of protons, malate ions and minerals and osmotic potential in the leaf cells of Bryophyllum daigremontianum"). There are diurnal oscillations of malate contents in the vacuoles of this plant ; the transport of malate depends, among other things, of the osmotic gradient, The action of drought is marked by variations of turgescence in transport of malate as well as of H± and K± ions (to be related to the role of these ions in stomatal movements).

Plants in C4 : indirect action of drought though bioregulators (N. SANKLA, W. HUBER : "Regulation of the balance between the cycles in C3 and the cycles in C4 : role of bioregulators"). Selective action of abscissic acid

(ABA) on the carboxylases leading to the reduction of the rate of CO_2 fixation (the ABA content increases when the plants are submitted to water or salt stress). There is a lowering of the RuDP carboxylase activity, but stimulation of the PEP carboxylase (the malate accumulates, the PGA (phosphoglyceric acid) decreases). One can therefore suppose that any factor affecting either one carboxylation or another will modify the type of CO_2 reduction. (RuDP = Ribulose Diphosphate ; PEP = phosphoenolpyruvate).
Plants in C4 : Water efficiency compared with that of plants in C3. (M. M. CALDWELL : "The carbon balance and water supply in cold desert communities dominated by plants with a photosynthesis in C3 and in C4"). Higher water efficiency with plants in C4 during the favorable growth period with a higher relationship : assimilation/transpiration than with plants in C3 (which have however a greater net assimilation). During the dry season the CO_2 balance remains positive in plants in C4 and is equal to zero or is negative in plants in C3 (other factors may interfere in plants in C4 : extension of root system, tendency to NaC1 accumulation).
Incidences of the aridity degree and of the type of $C0_2$ fixation on the geographic distribution of the species. 3H. H. TROUGHTON : "Water efficiency, photosynthetic cycle and ecological distribution of plants"). Plants in CAM withstand a higher aridity than the plants in C4, the latter more than plants in C3. Therefore in an arid zone, plants in CAM and in C_4 will be privileged compared to plants in C3, mainly thanks to a low mesophyl resistance of the former.

Enzymatic activity and ultrastructure.

(VIEIRA DA SILVA : "Enzymatic and ultrastructural effects of a water stress in the cotton plant"). Greater activation of lipases in drought sensitive cotton species than in resistant species. A greater reduction of thin cellular structures is also noted. There is a relationship between these reactions and the lowering of photochemical and activity of photorespiration.

. At the level of gas exchanges.

Physical factors of stomatal regulation.

Study of the relationship between the variation of stomatal resistance and the variation of the mean water potential in leaves, (A. E. HALL, M. R. KAUFMANN : "Regulation of water loss in plants"). (E. D. SCHULZE, 0. L. LANGE, M. EVENARI, L. KAPPEN, U. BUSCHBOM : "The role of air humidity and leaf temperature in the control of stomatal resistance in *Prunus armeniaca* in desert conditions"). The action of the "evaporative demand" is greater than the variations in the CO_2 content and the variations of the mean water potential of leaves (the water potential variations registered would simply result from the closing of the stomates).

Same results, showing the preponderance of temperature and of humidity differences between the ambient air and the leaf. CO_2 concentration, light intensity and water potential are not the most important factors, results obtained on isolated bits of *Polypodium vulgare* epiderm (LOSCH : "Effect of air humidity and temperature on stomatal movements").
Influence of mechanical pressure in hydropassive and hydroactive movements. (H. MEIDNER : "Relations between the functioning of stomates

and water at epiderm level"). Study of lateral water flux in epiderm cells : the value of the mechanical pressure is the same at the opening and closing of stomates.

. Physiological factors in stomatal regulation.

Drought and increase of the ABA content. (W. K. FERREL, J. BLAKE : "Effect of the water potential of soil and plant on the ABA content in Douglas Pine seedlings related to stomatic resistance"). A rise in the ABA content during drought accelerates the closing of stomates. After rehydration the ABA content rapidly decreases to the initial level, while stomatal resistance is slower to reach this level again.

(K. KRASCHKE : "Interactions between the response to CO2 and the moderate water loss "optimized" by ABA in Xanthium strumarium leaves"). ABA is supposed to act as an inhibitor for the explusion of the H± ions of the guard cells and to favour therefore stomatal closing. The presence of CO2 is necessary : stomates do not respond to ABA in a CO2 free air. Theory on the mechanism of stomatal regulation. (J. LEVITT : "The mechanism of stomatal action - an integration"). This theory explains the photoactive opening and the photoactive closing. Two main theories are

in presence : the old concept of the control by the pH and the more recent concept of the active absorption of ions. Each one relies on well-established facts, but remains incomplete since it cannot explain all of the known facts. The author combines the well-established components of each and adds to them well-established facts concerning other photosynthesizing cells, although not proved for guard cells. One concept is proposed based on : - electron transport in the form of :

$$ADP \pm P \text{ in equilibrium with } ATP \pm H^+ + OH^-$$

- active absorption of K ± ions with the intervention of ATP and phosphoenolpyruvate carboxylase ; - organic acid synthesis modifying the pH.

Incidences of stomatal regulation :

- on the control of transpiration and photosynthesis : special case for excised leaves (B. J. PHILLIPS, J. L. PRIOUL "Stomatal control of transpiration and photosynthesis after excision of Lolium multiflorum leaves"):study in relation to the sequence of physiological events after gathering. The most rapid physiological response is the closing of stomates. There is **a** strict correlation between the closing of stomates and the photosynthesis decrease.

- on the species behavior and distribution. (R. H. WARING, S. W. RUNNING : "Strategies of conifers for the adjustment to water stress"). Respective role of the stomatal conductance, of the use of water reserves stored in the album and/or in the heartwood and of the development of the root system on the distribution of conifers between the moist Pacific coast and the dry areas of the Rockies.

2. - Modelization of productivity and water consumption by plants.

. Adaptation in arid zones **(H.** van KEULEN, C. T. de WIT, H. LOF : "Use of simulation models in studies of productivity in arid zones").

Search for the best efficiency taking into account the transpiration coefficient :

$$T/P = \frac{\Delta e}{\Delta CO_2} \; \frac{r_{a'} + r_{s'} + r_{m'}}{r_a + r_s} \quad \begin{matrix}\text{(resistances to } CO_2 \text{ diffusion)} \\ \text{(resistances to } H_2O \text{ diffusion)}\end{matrix}$$

pe = gradient of the water vapor pressure ; A CO_2 = CO_2 gradient
(J. F. BIERHUIZEN : "Irrigation and efficiency").

. Correlations between primary productivity, precipitation and evapotranspiration. (H. LIETH).

. Stomatal response to complex perturbations of the ambient environment (determination of foliar conductance based on air humidity, leaf temperature, CO2 concentration, radiation). (I. R. GOWAN : "Analysis of stomatal response to environmental changes").

In conclusion we might add that this meeting brought together some 250 participants from 19 different countries. 140 papers could be presented ; the two symposia were held simultaneously.

The English summaries of these papers were published during the meeting. They are possibly still available from the Secretariat at the following address : "Botanische Anstalten der Universitat - 87000 Wurzburg, Mittlerer Dallenberweg 64 - Federal Republic of Germany).

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IV - SOUTHEASTERN PLANT ENVIRONMENT LABORATORIES (SEPEL - USA)

We have received varied documents from Prof. H. HELLMERS, Director of the Duke University Phytotron, from which we have extracted the following information for our readers :

"We are interested in using the facilities efficiently and to their best advantage in furthering the research needs of the scientific community. This raises several questions. One, are there other research uses or ways that the facility could be used to greater advantage ? Two, are there factors of the environment that should be controlled to a greater of lesser extent than we are now doing ? Three, is there a more efficient or economical way of controlling the environment conditions or of operating the facilities in general ? If you have any comments or questions, we would appreciate hearing from you. Also, if you have annual reports or periodic reviews of activities in your facility we would appreciate having copies".

Here is the address : Department of Botany, Duke University, Durham, North Carolina 27706, USA.

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A - A description of the SEPEL ensemble was published in "Bioscience, 1970, 20, p. 1201-1208".

B - From the 1973 Annual Report we have extracted the following information :

The increasing interest in environmental research seems to center around four general areas.

a - The classical interest of ecologists and physiologists in learning how environmental factors affect physiological processes and the growth and geographic distribution of plants.

b - The interest of agricultural scientists in understanding how climatic factors affect plant yields.

c - The strong interest of members of both groups in developing useful models of plant growth.

d - Increasing concern about the manner in which environmental factors modify the reactions of plants to various air pollutants.

Both the Duke and North Carolina State University units of SEPEL were used at close to their optimum working capacity during 1973. Both units are cooperating in a project financed by a grant from RANN to study the scientific and economic benefits of phytotron versus field research. The results of this study should be of great interest both to scientists and to research administrators who must plan and fund research projects involving the effects of environmental factors on plants.

1) - <u>At North Carolina State University unit.</u> J. C. STEVENSON and M. M. GOODMAN performed a series of experiments aimed at better understanding the ecology of exotic races of maize. Use of many of these races in breeding programs is severely limited by very late flowering and gigantic growth under field conditions at latitudes greater than about 30°. Most previous work with maize has been based on in-bred lines and various types of crosses and does not provide the information necessary to encompass a broad spectrum of tropical races. Short day lengths and cool temperatures can reduce excessive growth by inducing flower initiation at an early stage of development. Interactions of photoperiod and day night temperatures ranging from 10/6 to 34/30° were investigated in detail. Photoperiod proved to be more effective than temperature in decreasing the leaf number whereas temperature had the greatest influence on the number of tillers produced. Considerable difference in sensitivity to environmental control are being interpreted in terms of the original habitat.

Additional investigations clearly demonstrated the participation of the phytochrome system in the floral induction processes of maize. Phytochrome control plus short days and cool temperatures can be used to induce early initiation in these exotic races and it seems reasonable that preinduced material could be transplanted to the experimental garden with favorable results.

Much of the research in the NCSU Phytotron is coordinated with work in the field. A current effort headed by H. D. GROSS in cooperation with researchers from Botany, Crop Science and Soil Science Depth, is to attempt to understand the phenomenon of over-compensation. This term is used to describe an enhancement of yield when some varieties are planted together. Usually one variety will show an increased yield without a compensating loss by the other. The Phytotron phase of this study involves juvenile stage competition and the qualification of basic physiological mechanisms detected in the field studies.

In contrast with work exploring the nature of environmental influences on plant development, many experiments simply require a constant environment. R. C. FITES has been using the Phytotron constant environment rooms to map some of the biochemical changes that occur in the cotton seedling during its early development. Amino acids, protein, and total nitrogen as well as the appearance and/or changes in the activity of specific enzymes are being used to describe the cotton seedling through the transition from heterotrophic to autotrophic growth.

2) - At the Duke University unit. HESKETH has been concerned with the improvement of a general model for growth of cotton so that it will take into account various unusual environments such as that of the High Plains Region of Texas where temperatures are lower than in the Southeast. He has isolated some early flowering plants and plants which require a shorter than usual period for boll formation. Both characteristics are desirable in decreasing boll worm infestation.

HESKETH, HELLMERS and HOFSTRA have investigated the effects of enriching the air of growth chambers with CO_2 from the usual level of 300 ppm or less during the light period to 800 to 1000 ppm. This treatment greatly delayed flower initiation in four cultivars of sorghum and slightly delayed it in corn, sunflower, and cotton. It also was found that CO2 enrichment greatly increases the growth of soybean plants growing at an optimum temperature. Accumulation of starch in leaves of plants in a CO2 enriched atmosphere suppressed CO2 assimilation.

ANTONOVICS finds that use of the phytotron is opening up a whole new area of research in population genetics. It is enabling experiments involving crosses to be carried out at any season, greatly speeding up research involving crosses. More important, the variety of environments available makes it possible to study the amount of phenotypic plasticity in species originating in various environments. For example do plants of a species from a habitat normally experiencing wide variations in temperature in the field grow better over a wide range of temperatures in the phytotron than plants of a related species from **a** habitat normally subject to smaller variations in temperature ? ANTONOVICS and his students also are studying the growth rates and partitioning of energy in various plant parts in plants grown with various temperature regimes.

C In the 1974 Annual Report the following information appeared to be liable to interest our readers.

The demand for controlled environment space in the various units is making it difficult to obtain down time on the various units for routine maintenance. This problem has been overcome to some extent through modifications that have made the components such as fans more readily accessible. For instance, all the light cap cooling fans on the small chambers are now located on the outside of the unit. Thus, they now can be oiled or even replaced without removing or even turning off the lamps in the chamber.

Preventative maintenance along with modifications to increase reliability continue to produce an extremely high percentage of experiment failure. The only experiment lost in the two units was a photoperiod one that had to be started again after the main electrical switching gear exploded at the Duke unit. This was caused by the deterioration of the insulation which has now been replaced.

The deficiency of CO_2 concentrations in the chambers and greenhouses is being overcome through the installation of CO_2 monitoring and control systems that are being installed in both units.

At both units the experiments continue to become more complex and are conducted by a broader range of both on-campus and off-campus personnel as the capabilities of the Southeastern Plant Environment Laboratories become better known and understood.

Peo3le and space at the Duke University unit. The total number of scientists (57) using the facility in 1974 was the same as the previous year.

For the first time, one of the off-campus researchers is being financed by the Southern Regional Education Board. This organization is encouraging and financing scientists in the south to take advantage of unusual facilities in the region that are located on campuses other than their own.

The facilities continue to attract graduate students from eastern and western parts of the country as well as several foreign countries.

The average amount of controlled environment space utilized appears to have settled down over the years to approximately 30,000 square foot months which is about two thirds of the total available. However, this 30, 000 figure over a year represents full capacity use allowing for aisles in the greenhouses and the walk-in chambers plus down time between experiments for maintenance. A square foot month is the number of square feet used per month times the number of months used. Actual use during the course of the year will vary with some short periods of almost total use when even the aisles are filled with plants. These crowded conditions exist for only short periods, usually while plants are being established before being distributed to a range of treatments. Such use is not encouraged for extended periods as routine care of the plants is difficult and the variability of the temperature conditions increases slightly due to the obstruction of airflow.

The largest user of space over the year was the RANN Project. This is a project designed to measure and compare the quantity and quality of growth of several species of plants grown in the phytotron growth chambers, phytotron greenhouses and in the open. Cost records are being kept and the cost to benefit ratios for research for the three conditions will be determined.

Operations and equipment at the Duke University unit. This past year a concerted effort has been made to reduce energy consumption without hindering the usefulness of the operation.

The light ventilating fans on the small chambers have been moved to the outside for ease of maintenance. Also, this will permit the removal of any fans that fail without having to disrupt the experiment. Previously, the lamps had to be removed from the lamp loft in order to reach the fans.

Two years ago the pan of the cooling tower was converted to a wet sump, thus eliminating the sump tanks in the basement that flooded repeatedly. This past winter the water level control system froze. This should not occur again as the system is now insulated.

The CO_2 level in three large chambers and three greenhouses used previously by the RANN Project are now monitored and controlled. An infrared gas analyzer is used to monitor the units and a recorder was modified to control the solenoids that inject bottled CO_2 into the chamber or room if the reading is below the set minimum. During 1975 it is planned to increase the system to monitor and control the CO_2 level in all six greenhouses and the twenty large and medium sized chambers.

One of the two large dark chambers was modified to grow plants that require low light intensity. A network of incandescent lamps were installed to provide a uniform light level of 200 ft-candles.

November saw our first major equipment break-down in the almost seven years of operation. The main electrical switching gear in the transformer vault exploded on two consecutive days. The fault was finally determined to be the deterioration of the insulation on one of the switches. Since it has been replaced, no further trouble has been encountered. A roof will probably be placed over the vault in the near future to protect this equipment from the weather.

As would be expected the continuous operation of the equipment since the opening of the phytotron is resulting in an increasing rate of failure of pump seals and couplings as well as fans. Practically all of the more than 600 muffin fans have been replaced.

As insulation on the cold ethylene glycol and chilled water pipes begins to fail, it is being replaced with armoflex to provide better insulation and thus to reduce the load on the chillers.

With the exception of the complete power failure, none of the smaller equipment repair or replacement caused a major disruption of experiments. The chambers held their temperature quite well during the power outage but several photoperiod experiments had to be started again. Also, the plants had to be moved out of the normally cooler greenhouses due to the heat build-up from the sun.

Methods of conserving energy are continually being sought and some changes have been implemented. In addition to turning off building lights and lowering thermostat settings the warmest greenhouse (32°C) was turned off for the winter. This was possible because the two warmest greenhouses have been used primarily by the RANN Project during the summer for a comparison between open grown and greenhouse grown plants. Their remaining plants and the space requirements of others could be combined and met in a 29°C greenhouse during the winter. When the field work starts again the greenhouse space needs will also increase and the unit will be restarted. A small building modification was made to save office-space heating energy. The engineers had designed the heating system with both the supply and return ducts in the ceiling. This arrangement made it impossible to heat the lower level of the room without consuming a large amount of energy. The wall and the return air duct to the heat exchanger in the basement were cut at floor level. A grill was placed in front of the opening, the ceiling return air ducts were closed and the office doors are left open to allow the air to flow to the return grill. Additional changes and possible sequencing of conditions are being considered to lower both the total energy consumption and the peak load.

Work has also started to install a central seven-day variable temperature controller for the growth chambers.

The NCSU Phytotron unit.

Public relations continues to be an important, and time consuming, role of the Phytotron staff. The public, lay and scientific, prove to be especially interested in the research and contributions of visiting scientists and the support roles of the National Science Foundation and the Agricultural Experiment Station. As in past years, the NCSU Phytotron was shown to over 200 visitors. In addition, an "open house" was held for people attending the Tobacco Chemists Research Conference, Garden Writers Association and commercial and scientific persons attending the International meeting of Bedding Plants Inc.

Research programs during 1974 increased to the point that no space was available for maintenance down-time. New programs had to wait as much as two months for space.

Of particular interest is the effort of C. D. RAPER, Jr. to work out a dynamic model of plant growth. A logical off-shoot of an earlier study that developed a model environmental program for growing "normal" plants, tobacco was selected because of the great wealth of existing knowledge of biochemical and morphological events that occur during the normal growth sequence. The primary objective of RAPER's study is to "model the processes of photosynthesis, respiration, transpiration, nutrient and photosynthate translocation and growth at tissue and organ levels". The model will be responsive to environmental input and will be applicable to field, greenhouse or growth chambers.

Interest in air pollution research continues unabated. A cooperative program resulted in a series of studies to determine the effects of air pollutants, especially ozone, on legume nodulation. Special emphasis was given to the soil system and how it directly or indirectly is modified by ozone. Leghemoglobin content, root exudates, activity of Rhizobiurn were investigated as well as lignin, cellulose and root structural modifications.

Pathology investigations are included in the NCSU Phytotron and researchers in this area have been especially active ; the research usually being limited in scope because of lack of facilities for this purpose. Where very specific organisms are involved we decided to test use the general area of the Phytotron. Dr. KUHLMAN's study of Cronartium rust of pine is an example of what can be done. The objective was to determine the role of photoperiod and temperature on the sensitivity of a range of resistant to susceptible host material to infection by fusiform rust organism. Six day/night temperature combinations, each with long and short photoperiods were used in the Phytotron. Simultaneously, a one-temperature, three-photoperiod study was conducted in the forestry greenhouse,

A mosaic virus specific for oats does not affect plants without a fungus vector. While neither the fungus nor the virus alone seem to cause the disease, together, they sometimes result in the mosaic. Environmental conditions for infection appear to be limited to a very narrow range of temperature and daylength. Dr. HEBERT proceeded with a series of experiments that attempted to delineate the role of environment in this complex relationship of virus, fungus and host.

Studies continued by Dr. MORELAND to develop a better understanding of the modulation of metabolism by energy relations within the germinating seed by following changes in AMP, ADP and ATP. Relative contribution of glycolysis and oxidative phosphorylation to the ATP pool were also examined.

Another study investigated the optimum conditions for nitrate reductase activity to determine if NR was coupled to carbohydrate metabolism in the same way in nodulating and no-nodulating species.

Light mediation of nitrogen reductase activity is not well understood. Mr. ANDERSON set up a series of studies to characterize the biochemical aspects of light-activated NR, determine the degree of regulation by phytochrome and the phytochromic influence on cytoplasmic ribosomal activity.

1974 research efforts ranged from biochemical to agricultural and from basic to applied. In some areas research programs had to be altered to fit the equipment ; the very problem a Phytotron should be able to avoid. An example might be made of Dr. SINGH's effort to determine the environmental factors that affect yield and seed quality of soybean. To quote liberally from his proposal : seed produced in India at high elevation (and cool temperatures) are of much better quality than those produced on the plains. Seed quality improves if the seed are planted late when temperature and RH are lower. Mr. SINGH notes that the large percentage of shrunken seed which lose viability very rapidly in storage is a major constraint to soybean production in India. The Phytotron should have been capable of reproducing the temperature, RH conditions of any place or time in India but we failed because we lacked sufficient RH control. As a result, the study was only marginally effective in reaching its objectives.

Editors' note. This very interesting and objective report has incited us to ask all Phytotron directors to be so kind as to send us their reports or summaries for diffusion. This would certainly facilitate exchanges of information on research means. For example : conditions for relative humidity are controlled perfectly at Gif-sur-Yvette.

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V - PHYTOTRON AT THE EXPERIMENTAL FARM OF THE UNIVERSITY OF PRETORIA (South Africa)

Dr. P. S. HAMMES, of the Department of Plant Production sent us some reports from which we are pleased to reproduce for our readers following information.

This phytotron has been functioning for approximately five years and at present consists of eight glasshouses and 15 large (± 3 m^2) plant growth chambers. Some time has been spent to study light and temperature conditions in the growth chambers. Temperature variations in space and time under various experimental conditions have been measured with shaded thermocouples. The effect of variations in the day-night temperature regime on the temperature of the growth medium in the containers were also determined. In general a difference of 10°C between day and night temperatures resulted in a time lag of approximately two hours before the containers reached equilibrium temperature.

Two different research programs are at present being conducted in the phytotron :

Prof. P. C. NEL is in charge of the research on herbicides. Special attention is given to the herbicide : plant : environment interactions.

Dr. P. S. HAMMES is in charge of research on Crop Physiology. This program includes the role of light and temperature on the growth and development of agronomic crops. Good progress has already been made in work on the process of tuberization in potatoes and on the problem of poor pod development in dry beans (*Phaseolus vulgaris*).

In the publication "Tegniese Mededeling", n° 113, 1973, Department von Landbou - Tegniese Dienste of the University of Pretoria, P. S. HAMMES, E. A. BEYERS and P. C. NEL describe the installations in an english summary which we publish below :

Phytotron facilities for agricultural research. Phytotrons are of increasing importance in agricultural research, and a knowledge of the characteristics of phytotrons, including the operation, utilization, and limitations is therefore essential. A typical small phytotron is in operation on the Experimental Farm of the University of Pretoria. At present it consists of 8 glasshouse compartments with evaporative cooling, and 15 plant growth chambers (Fig. 1).

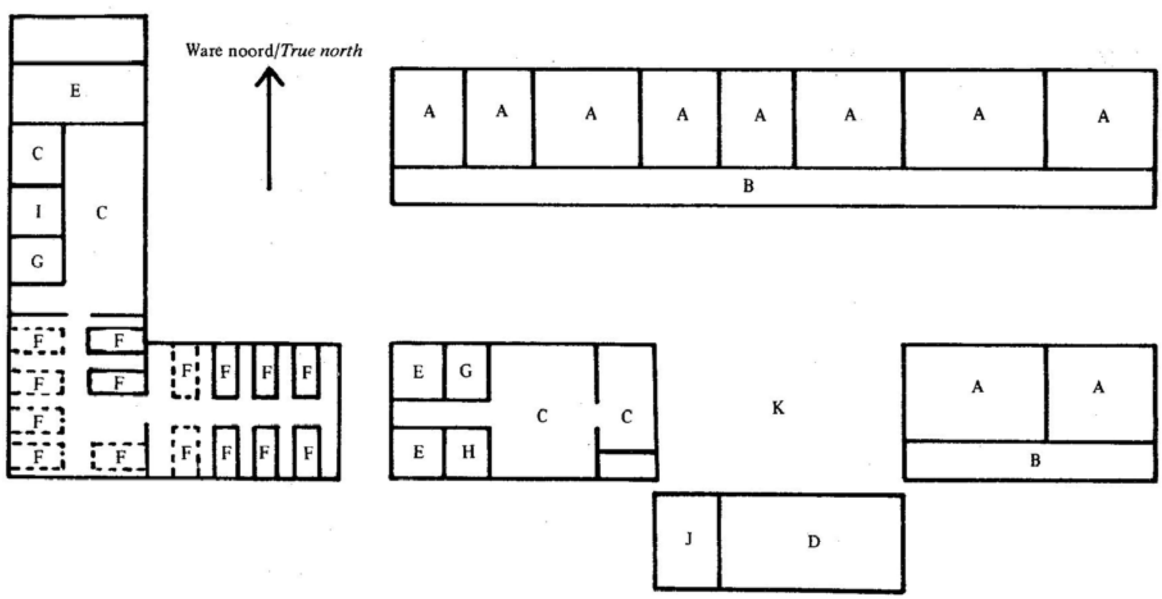

FIG. 1 – Plan-uitleg van 'n klein fitotron soos dié op die Universiteitsproefplaas, Pretoria (skaal: 3 mm = 1 m)/*Lay out of a small phytotron such as the one on the University Experimental Farm, Pretoria (scale: 3 mm = 1 m)*

A – Glashuiskompartemente/*Glasshouse compartments*
B – Masjienkamers en stoepe/*Conditioning plants*
C – Laboratoria en voorbereidingskamers/*Laboratories and preparation rooms*
D – Potstoor/*Storage space for pots, sand, etc.*
E – Kantore/*Offices*
F – Groeikaste (stippellyne dui op toekomstige uitbreiding)/*Growth chambers (dotted lines indicate future expansion)*
G – Stoorkamers/*Store rooms*
H – Skaalkamer/*Weighing room*
I – Droogkamer/*Room for drying ovens*
J – Lokaal vir grond-outoklaaf/*Room for autoclave*
K – Sementblad werkoppervlakte/*Working area*

The evaporative cooling system in the glasshouses can keep the temperature down to 32°C during a hot summer day, whereas an electrical heating system can raise the temperature to approximately 14°C during frosty nights. Air velocity one meter above the floor is 40 m per minute. Although large temperature variations in time occur, temperature variation in space is limited to approximately 4°C in the same horizontal plane. Maximum light intensity during summer is 44, 5 mW/cm^2, and during winter 29, 5 mW/cm^2. Fluorescent and incandescent lights, operated by a time switch, facilitate control of the photoperiod.

The growth chambers are of the "Controlled environments" PGW36-type with a growing area of 3, 4 m^2 and an internal height of 1, 8 m. With all lights off temperature control is very accurate. With the lights on an appreciable degree of variation in temperature occurs, as illustrated in Tables 1 and 2 and Fig. 5. This is probably due to radiation effects as well as inefficient air circulation. In the centre of the growth chamber a vertical temperature gradient of 4°C per meter was recorded - a fact that should be borne in mind when experimenting with tall-growing crops such as maize, Radiation also results in an increase in the temperature of leaves and other plant organs, and of plant containers.

Table 1 - Temperature measurements in a growth chamber at different positions and with different lighting combinations.

Distance from the lights	Lighting combination	Temperature		
		Average (1)	Highest	Lowest
cm		°C	°C	°C
150	F_3I_0 (2)	20, 3	21, 5	19, 6
	F_0I_3	20, 1	20, 6	18, 6
	F_3I_3	22, 8	24, 0	21, 0
120	F_3I_0	21, 6	22, 6	20, 0
	F_0I_3	20, 0	21, 2	19, 0
	F_3I_3	22, 9	25, 6	21, 5
90	F_3I_0	21, 8	24, 5	20, 3
	F_0I_3	21, 2	24, 0	20, 1
	F_3I_3	25, 3	30, 0	22, 5
60	F_3I_0	23, 2	26, 8	20, 3
	F_0I_3	22, 2	24, 9	20, 0
	F_3I_3	27, 1	32, 8	23, 0

(1) Average temperature recorded by 12 exposed thermocouples spaced in the same horizontal plane.

(2) F_3I_0 : three sets of fluorescents and no incandescents are on.
F_0I_3 : three sets of incandescents are on.

Table 2 - Light intensity in growth chamber with various combinations of the lights (1)

combination of lights (2)	lux-value (lux)	light intensity calculated radiation (m W/cm^2)
F_3I_3	42 000	19,1
F_2I_2	30 000	13,6
F_1I_1	16 000	7,3
F_3I_0	40 000	18,2
F_2I_0	28 000	12,7
F_1I_0	15 000	6,8
F_0I_3	3 600	1,6
F_0I_2	2 500	1,1
F_0I_1	1 300	0,6

(1) Measurements in centre of chamber, 1 m from the lights.
(2) F = fluorescents ; I = incandescents ; 3 = 3/3, 2 = 2/3, 1 = 1/3 of total number of lamps.

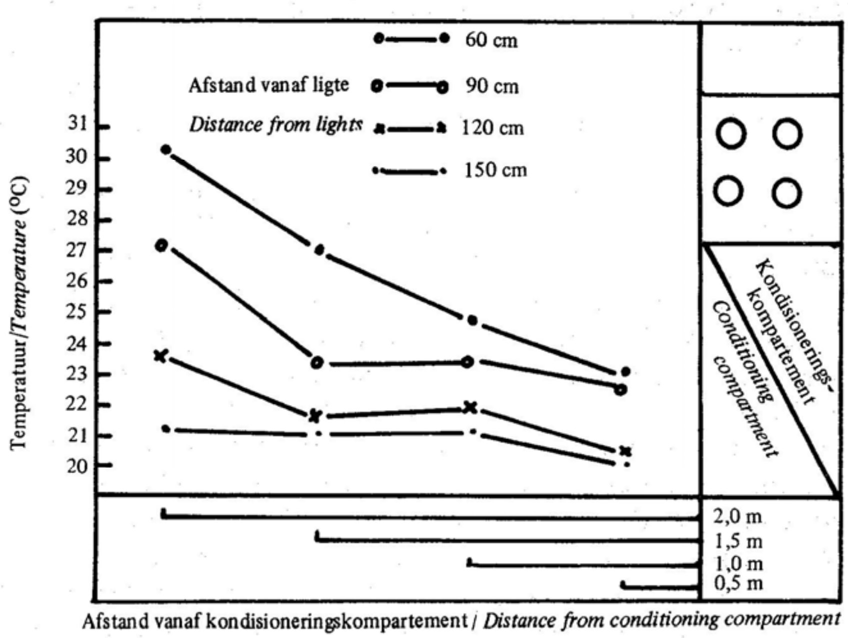

FIG. 5 – Gemiddelde temperatuurlesings (drie punte) op verskillende posisies in groeikas, en op verskillende afstande vanaf die ligte/*Average temperature (three points) at different positions in growth chamber and at varying distances from the lights*

A maximum light intensity of 18, 2 $mWicm^{2}$, 60 cm from the lights was measured after the lights had been on for 1 000 hours. The intensity decreased by approximately 10 % if the ambient temperature was raised from 10° to 30°C. (There is no barrier between the growing area and the lights). The vertical gradient in light intensity is about 30 % per metre. In the same horizontal plane light intensity is fairly uniform, except towards the walls of the chamber. A decrease of up to 15 % occurs 10 cm from the sides, light quality from the fluorescent and incandescent lamps is satisfactory for plant growth in general. This was confirmed by growth experiments with a variety of crops.

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VI - THE PHYTOTRON OF THE OSLO UNIVERSITY

(Stein Nilsen - University of Oslo - Blindern, Postbocks 1066, Oslo 3, Norway).

The phytotron is an independent unit within the University of Oslo. Its primary goal is to serve as a tool in the University's teaching and research program. Assignments can also be carried out for external users.

The phytotron came into use in March 1973, and is today fully operational. The total construction costs were about one million £, including the building. This building adjoins the University's new Biology building. The total area of both together is about 36.000 m^2, of which the phytotron itself covers 3.300 m^2 divided into two floors, and of which 500 m^2 is for plant cultivation. A research site of 8. 000 m^2 is attached to the Phytotron.

The climatic section (fig. 1) comprises 16 fully conditioned chambers with artificial lighting (1-16) 10 m^2 each, 6 fully conditioned natural light greenhouses (A-F) 26 m_2 each, as several deep-freeze and refrigerated rooms, and air conditioned laboratories (I-IX). In the fully conditioned climatic chambers 108 light tubes (Philips TLMW/33RS 140 W) are fitted into the ceiling, separated from the room itself by plexiglass. The light tube sections are air cooled by a central fresh-air conditioner (fig. 2). The light regulation system is placed in two specially cooled rooms. The light in each climatic chamber can be varied from 0-40. 000 lux by a programmed successive addition of groups of light tubes and by regulation. This allows a smooth and continuous variation of the light with no change in distribution. The climatic aggregates for the conditioned chambers are, in principle the same, but differ in capacity. From the main vent pressurized air is forced through the floor of the chamber. The floor is perforated, curbing the circulation, and provides an even air distribution throughout. The air is led via an opening at the back of the chamber, through a canal, and back to the aggregate. Here the air passes a cooling battery, a heating battery, and a humidifier, after which the air is returned to the main vent (as shown in fig. 2).

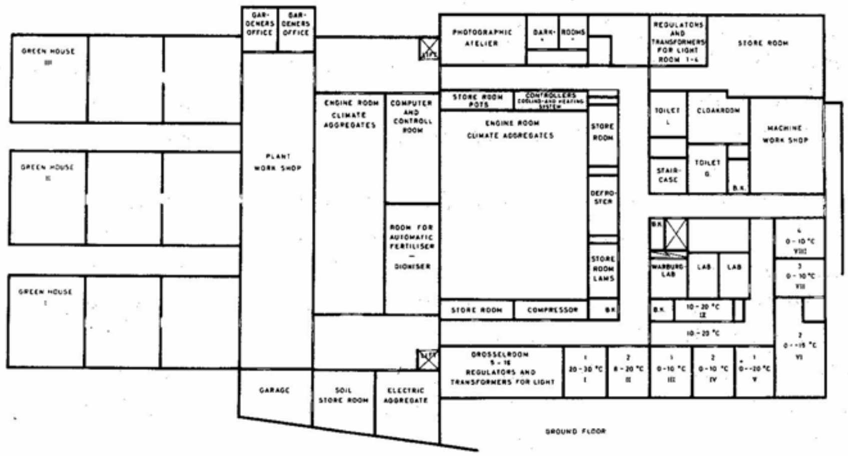

GAR-DENERS OFFICE
GAR-DENERS OFFICE
GREEN HOUSE III
GREEN HOUSE II
GREEN HOUSE I
PLANT WORK SHOP
ENGINE ROOM CLIMATE AGGREGATES
COMPUTER AND CONTROLL ROOM
ROOM FOR AUTOMATIC FERTILISER — DIONISER
GARAGE
SOIL STORE ROOM
ELECTRIC AGGREGATE
PHOTOGRAPHIC ATELIER
DARK- ROOMS
REGULATORS AND TRANSFORMERS FOR LIGHT ROOM 1-4
STORE ROOM
STORE ROOM POTS
CONTROLLERS COOLING- AND HEATING SYSTEM
ENGINE ROOM CLIMATE AGGREGATES
STORE ROOM
DEFRO-STER
STORE ROOM LAMS
STORE ROOM
COMPRESSOR
B.K.
TOILET L.
CLOAKROOM
MACHINE WORK SHOP
STAIR-CASE
TOILET G.
B.K.
B.K.
WARBURG-LAB
LAB
LAB
4 0 - 10 °C VIII
3 0 - 10 °C VII
B.K.
10 - 20 °C IX
10 - 20 °C
2 0 - -15 °C VI
GROSSELROOM 5 - 16 REGULATORS AND TRANSFORMERS FOR LIGHT
1 20 - 30 °C I
2 8 - 20 °C II
1 0 - 10 °C III
2 0 - 10 °C IV
1 0 - -20 °C V
GROUND FLOOR

Fig. 1

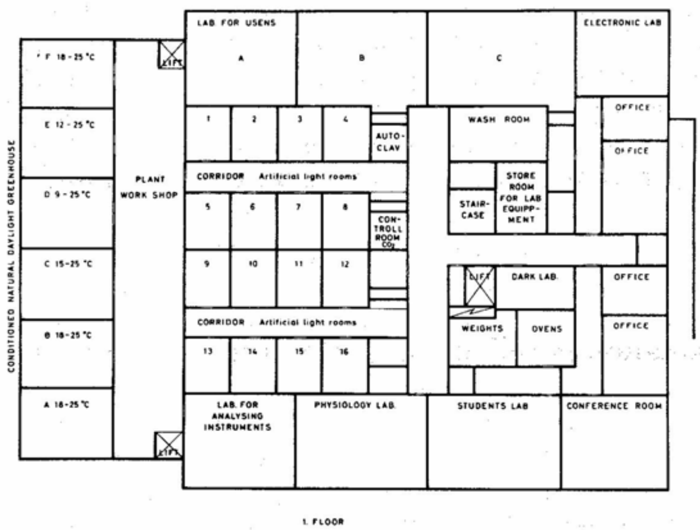
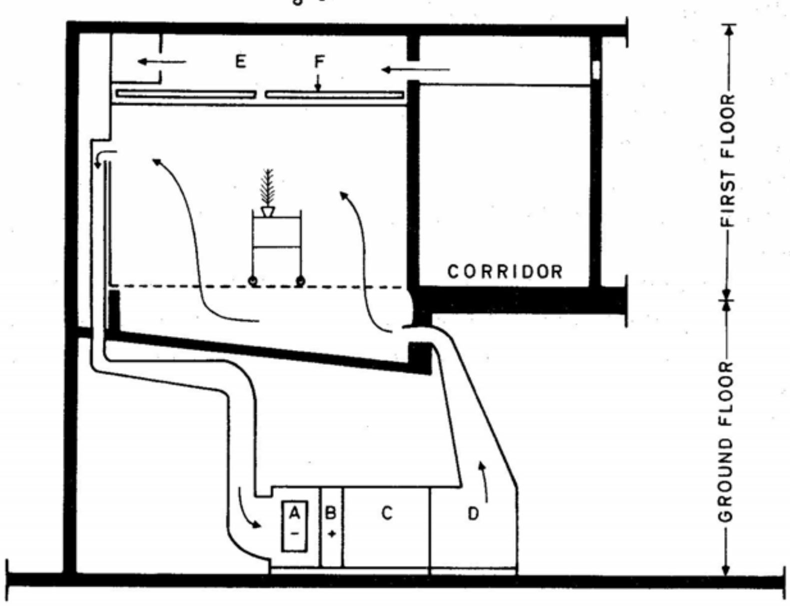

CONDITIONED NATURAL DAYLIGHT GREENHOUSE
F 18 - 25 °C
E 12 - 25 °C
D 9 - 25 °C
C 15 - 25 °C
B 18 - 25 °C
A 18 - 25 °C
PLANT WORK SHOP
LAB FOR USENS
A
B
C
ELECTRONIC LAB
1
2
3
4
AUTO-CLAV
CORRIDOR Artificial light rooms
5
6
7
8
CON-TROLL ROOM CO_2
9
10
11
12
CORRIDOR Artificial light rooms
13
14
15
16
WASH ROOM
STAIR-CASE
STORE ROOM FOR LAB EQUIPP-MENT
DARK LAB.
WEIGHTS
OVENS
OFFICE
OFFICE
OFFICE
OFFICE
LAB. FOR ANALYSING INSTRUMENTS
PHYSIOLOGY LAB.
STUDENTS LAB
CONFERENCE ROOM
1. FLOOR

Fig 2.


E
F
CORRIDOR
A
−
B
+
C
D
FIRST FLOOR
GROUND FLOOR

Each aggregate carries 10 % of the circulating air as dehumidified fresh air. The cooling and heating batteries are connected to a central heating and cooling system by shunt valves. Thermostats in the air canals issue impulses via electronic, automatic units to the shunt valves, whereby the required temperature is obtained. The humidity is also automatically regulated. The temperature in the climatic chambers can be varied between 5 and 35°C within ± 0. 2°C.

The six daylight rooms have independent temperature controls (see fig. 1). The room temperature can be varied from 9-25°C. The humidity for all the rooms can be varied from 40-90 % within ± 5 %. The CO2 concentration in the rooms is registered by an infrared CO2 analyzer (URAS II). No regulation is possible.

Each climatic chamber and daylight room has its own automatic ventilation and control. From these (22 units in all) data are transferred to a control center from which temperature and humidity is controlled. Switches for pumps and fans of the aggregates, and recorders of temperature, humidity and light, etc. are located on the same control panel.

The control unit is connected to a processing computer which adjusts all parameters to a desired program, registers conditions in the rooms, excerpts and generally controls. Light intensity can be varied continuously with time, and dusk and dawn effects can be achieved. Temperature and humidity can similarly be varied with time within the capacity of the aggregate.

Besides climatic chambers the phytotron has a greenhouse division made up of three greenhouses, each of 150 m^2. These have automatic temperature and humidity regulators. Further, an outlet for deionized water and nutrient regulation is installed. (This is found in all the cultivation rooms). A central supply of deionized and nutrient solution is kept in a separate room. There are three tanks for nutrient solutions, each 4 ma, and a deionizing plant with 30 m^3 capacity between regenerations.

Part of the running costs of the phytotron are covered by outside users. The rent at present is about £ 3 per room, per day. This rent covers only the expenses of changing light tubes and computer operation. All other running costs are borne by the University.

A staff of seven run the phytotron, comprising one department head, one scientific assistant, one electronic engineer, two gardeners, one mechanic, and one laboratory assistant. Large projects are run by means of temporary staff.

At present the capacity is nearly filled. In 1974 a total of 3000 room-days was recorded. In 1975 we expect to reach full capacity, ca. 5,000 room-days.

Research over the past two years of operation has centered on the following subjects : growth and overwintering tests with spruce seed plants ; genetic studies of barley ; investigations of photosynthesis and photorespiration in spruce.

VII - EXPERIMENTAL RESEARCH IN CONTROLLED ENVIRONMENTS IN RELATION TO THE PERENNIAL GRASS CROP

(G. J. A. RYLE, E. L. LEAFE, M. J. ROBSON and Jane WOLEDGE - Botany Division, Grassland Research Institute, Hurley, Berkshire, U. K.).

The intensively managed perennial grass crop has a characteristic dry weight production curve. In the spring, or following recovery from cutting, there is an initial phase of increasing growth rate which quickly leads into a second phase when growth rate is fairly constant. Finally, towards the end of each growth period, growth rate declines and yield reaches a ceiling and may even decline if the crop is not harvested.

An account is given of how phytotronic and controlled environment techniques are being used to analyze and understand the primary processes and morphological changes which occur in grass crops, and to determine how factors in the crop and the environment limit yield.

Investigations of the grass crop in the natural environment include direct measurements of photosynthesis and respiration of the canopy in relation to its microclimate. A related series of investigations deal with the growth of simulated small grass crops grown in controlled environment rooms where the illumination, photoperiod, water and nutrient regimes can be kept constant. In this situation, continuous measurements of changes in crop morphology and carbon dioxide exchange rates are supplemented by direct measurements of light interception, root respiration and death and detachment of plant tissue.

At yet another level of investigation, the gas exchange characteristics of single leaves are examined to determine how their physiological age, position in the canopy and early environment affect their performance. The effects of some of these factors are analyzed by experimentation with single plants.

In yet other investigations in controlled environment cabinets, gas exchange and quantitative isotope techniques are used to determine the entry of carbon into single axis (uniculm) plant systems, the loss of carbon due to synthetic and maintenance respiration, and the partitioning of the remaining assimilated carbon to growing leaves, stem and roots to provide a comprehensive picture of the total carbon flux.

The pattern of growth of any crop in the natural environment is complex ; that of the perennial herbage grass crop intensively managed for high productivity is extremely complex. In the past, the- performance of such crops has been carefully measured in terms of the characteristic patterns of production of harvestable dry weight, and analyzed against a background of the classical theory of growth analysis. However, this approach has shed little light on the primary processes involved or their inter-relationships with a rapidly fluctuating natural environment.

This paper illustrates the techniques now in use in the Botany Division at the Grassland Research Institute and the way they are being utilised to analyze the primary processes and morphological changes which occur in grass crops.

The most important attribute of the crop is the pattern of change of dry weight. To understand how changes of dry weight come about, it is necessary to measure the rates of the primary processes of carbon exchange and accumulation and how these are influenced by the physical environment and the changing structure of the crop canopy.

The direct measurement of carbon fluxes in the grass crop grown in the normal field situation has been approached by developing a mobile apparatus which can measure the rates of CO2 exchange by enclosing a square plot of grass of 50 cm side. The technical details of this apparatus have been published in full elsewhere (LEAFE, 1972) ; it is sufficient to point out here that measurements can be made of net CO2 uptake in the light and of respiratory losses in the dark (Fig. 1) throughout the development of the sward in near-natural conditions of light and temperature.

However, there are several aspects of the carbon balance sheet of the crop which cannot easily be resolved using this technique. Firstly, the apparatus is designed to exclude the CO2 arising from root and soil respiration, and measurements of root respiration cannot therefore be made. Secondly, leaves die in grass swards, especially in the later stages of development and this material is not easily recovered for measurement as it is rapidly incorporated into the soil. Thirdly, rapid fluctuations in the natural environment impose some limitations on the accuracy of gas exchange determinations.

To complement these field measurements made in the natural environment, and to provide data on those processes which cannot be measured at all in the field, we have used simulated swards in the controlled environment room (ROBSON, 1971). The simulated swards are contained in square metal boxes of the same dimensions as the plots sampled in the natural grass swards. Thus the mobile enclosure apparatus can be used to measure photosynthesis and respiration in the simulated swards as well as in the field. The simulated swards can be grown in soil or in Perlite - an inert rooting medium which contains no natural nutrients. In the latter case, the rooting medium is irrigated automatically once daily with a nutrient regime with control of the major nutrients.

Thus far most experiments have been concerned with the growth of spaced seedlings from germination to leaf area indices of 15-20, i. e. until the leaf surface was 15-20 times that of the ground area on which the plants were growing (ROBSON, 1973a). The major environmental variables have been light (30 to 120 Wm^{-2} - 400-700 nm) and temperature (12. 5-22. 5°C). Perhaps the most important results from this work have been direct estimates of root respiration and of the dead material which accumulates during the development of a canopy. Together with other measurements obtained in controlled environments (ROBSON, 1973b), these have allowed the calculation of a much more accurate balance sheet of carbon gains and losses during sward development (Fig. 2).

In the simulated swards, total respiration (shoot and root) can be estimated by blocking the exits at the base of the metal boxes so that the forced ventilation of the enclosure takes account of the CO2 exchange in the Perlite of the rooting medium as well as that of the aerial parts of the sward. When these exits are open, the atmosphere in the rooting medium is vented and the IRGA measures only the CO2 exchange from the above-ground parts. By difference, an estimate of root respiration can be obtained. Subsequently, the whole of the root system can be recovered for dry weight determinations. Culture of the simulated swards in artificial growth media thus determinations. Culture of the simulated swards in artificial growth media thus largely eliminates the respiration of soil micro-organisms and its attendant problems. In addition, the absence of earthworms and soil flora and fauna results in the accumulation of dead leaf and litter above the rooting medium from where it can easily be recovered to determine the magnitude of this carbon loss from the system.

Fig. 1 Cumulative canopy net photosynthesis (Pn,C), shoot dark respiration (Rs,d,c) as hexose equivalent and dry weight (D.W.) in a natural sward of perennial ryegrass.

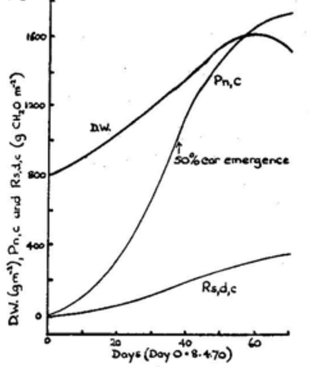
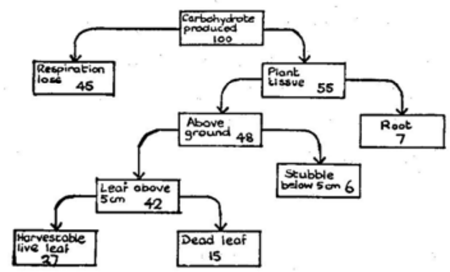


Fig. 2 Carbon balance sheet for S.24 perennial ryegrass grown as a simulated sward. Mean performance over 12 weeks in a controlled environment room.

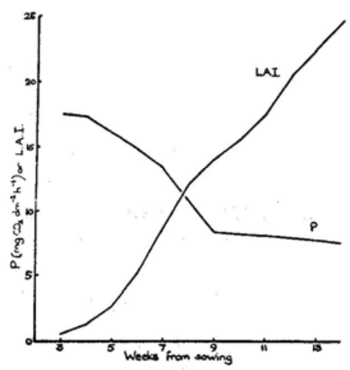


Together these two approaches have provided a continuous account of the net photosynthesis of sward canopies during their development, as well as of estimates of carbon losses due to respiration and death and detachment of leaves, which have accounted reasonably well for the observed dry weight changes in the crops. However, measurements of primary processes have brought to light hitherto unexpected shifts in some attributes. Thus it can be seen in Fig. 1 that the rate of dry weight increase of the grass crop flattens off and then declines after a sustained period of linear growth (cf. ALBERDA and co-workers, 1968), partly due to an increasing rate of leaf death and detachment. However, this cessation of weight gain is also accompanied by a fall in the rate of net photosynthesis, while respiration also begins to decline. Continuous monitoring of the crop microclimate indicates that the fall in crop assimilation is not principally due to changesin the external environment. A more important factor is the decline in the photosynthetic efficiency of the canopy. This may be due to the development of an unfavourable spatial distribution of leaves in relation to radiation, to changes in the age of those leaves which intercept the radiation, or to changes in the photosynthetic efficiency of leaves.

The gas exchange performance of individual leaves from crop canopies is not a question which can easily be resolved in sward conditions. A programme was therefore developed to examine the attributes of single grass leaves in controlled environment cabinets. Initially, this program was concerned with determining the influence of light intensity, temperature and leaf age on the rate of net photosynthesis and respiration of leaves on single plants grown in pots (WOLEDGE, 1971, 1972). More recently, emphasis has been laid on determining the importance of light intensity in the microclimate of the sward, where it seems light may limit the assimilation rate of a leaf by its influence during leaf development, as well as by limiting its performance when the leaf is fully expanded.

Fig. 3 shows how the rate of net assimilation of successive recently-expanded leaves declines as the canopy develops in a simulated sward and the leaf area index increases to more than twenty. When an examination was made of the performance of similar leaves borne on the main axes of single potted plants, and protected from shading during their growth, there was little or no change in assimilation rate, indicating no ontogenetic drift in this physiological characteristic in leaves developed from successively higher nodes on the shoot axis (Fig. 4). Thus, it seems that where assimilation rate declines in swards, one cause may be that new leaves are progressively more heavily shaded during their development and this reduces their ability to assimilate at a high rate when they are fully expanded and exposed to full light. Support for this view was obtained by growing plants at different densities in small pots (Fig. 5). Here again, the assimilation rate of specific leaves measured in a high light intensity declined with increase in density of adjacent plants spaced around the parent shoot.

Fig. 3 Net assimilation rate of the youngest expanded leaf of simulated ryegrass swards



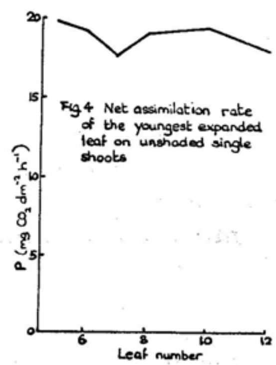


Fig. 4 Net assimilation rate of the youngest expanded leaf on unshaded single shoots

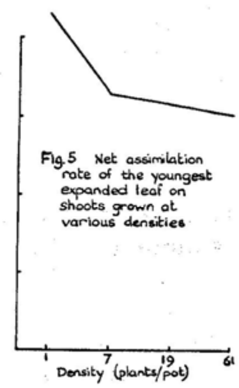


Fig. 5 Net assimilation rate of the youngest expanded leaf on shoots grown at various densities

The investigations already described deal primarily with questions of photosynthesis and respiration in grass plants. However, a very important and somewhat neglected aspect of crop physiology is that part which is concerned with the destiny of carbon after it has entered the plant system. The Division's programme dealing with assimilate distribution was initially directed towards determining how much assimilate each leaf on the main shoot of single plants (Lolium temulentum) contributed to the growth of leaves, stem, tillers and roots during a period of vegetative or reproductive growth in controlled environments. The patterns of assimilate distribution in those *grass* plants are complex ; details of the shifts in assimilate flow during the expansion of four or five consecutive leaves, and of the differences observed when an elongated stem and an inflorescence are developed are given elsewhere (RYLE and POWELL, 1972 ; RYLE, 1972). Radioisotopic carbon was used as the tracer for the identification of assimilate desti nation, whilst infra-red gas analysis was used to determine the absolute amount of carbon involved. These analyzes drew attention to the substantial losses of assimilate sustained during the processes which intervene between the entry of carbon dioxide into the leaf surface and the synthesis of structural compounds in regions of meristematic activity. An attempt was made therefore to find a suitable graminaceous plant, consisting of a single axis, which could be grown in rigidly controlled environmental conditions and which could be used to determine by direct measurement the major processes which influence the flux of carbon in the plant and the accumulation of dry weight in each meristematic region. A uniculm variant of barley (Kindred Uniculm 97) was chosen as the test plant and measurements were made at each leaf increment interval from the fifth to the tenth leaf of leaf net assimilation rate, leaf areas, synthetic respiration losses, and assimilate distribution to meristems. These and other subsidiary data are used as the biological inputs in a computer simulation programme of plant growth which predicts leaf, stem and root growth (RYLE, BROCKINGTON, POWELL and CROSS, 1973).

Comparisons of the predicted and observed growth rates in the uniculm barley plant for one choice of environment indicate that the model does provide a realistic picture of the growth rate of the whole shoot and of the growth of the three regions of meristematic activity (Table 1). In addition the model also indicates that about a third of current assimilate is lost in synthetic respiratory processes within 24 h of its formation in the leaf, and that the equivalent of a further 10-20 % of the plant's daily assimilate is lost due to that respiration associated with maintenance processes.

These observations of respiratory losses of carbon in the single-axis plant are being examined to determine their relevance to associations of grass plants in simulated and natural swards.

Table 1 - The predicted and observed rates of growth (mg CH2O equiv. day^{-1}) of leaf, stem and root during five consecutive periods in uniculm barley.

Expanding leaf		5L	6L	7L	8L	9L
Leaf	predicted	54	68	74	82	79
	observed	86	74	80	97	86
Stem	predicted	5	8	12	17	20
	observed	4	7	10	23	24
Root	predicted	29	39	45	44	35
	observed	27	39	32	38	34
Total	predicted	88	11.5	131	143	134
	observed	117	120	122	158	144

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VIII - ROOT TEMPERATURE CONTROL IN PHYTOTRONS 1

(G. I. MOSS, E. S. TRICKETT and S. P. PATERSON - Commonwealth Scientific and Industrial Research Organisation, Division of Irrigation Research, Private Bag, Griffith, N. S. W. 2680 Australia).

Root environment in relation to the environment of the shoot has been neglected in phytotron work. Where air temperature of the whole plant is closely controlled, temperature of the root medium can be surprisingly different (ICNIEVAL, D. P. , 1973, Agron. J. , 65, 398-99). Likewise attempts to control root temperature can affect the shoot environment (Table 1). The importance of this difference in experiments on the effect of temperature on plant physiology is not sufficiently recognized.

TABLE 1

SOIL, LEAF AND AIR TEMPERATURES* OF ORANGE PLANTS IN A GLASSHOUSE AS INFLUENCED BY TWO METHODS OF CONTROLLING SOIL TEMPERATURE

Soil (pot) temp. condition	1. Ambient - on glasshouse bench			2. Pot in enclosed water bath (temp. controlled)			3. Pot in open water bath (temp. controlled)		
Time of day and mean	03.45	13.45	Mean of 24 hours	03.45	13.45	Mean of 24 hours	03.45	13.45	Mean of 24 hours
Soil temp. (10cm)	13.6	23.5	17.8	28.2	27.2	28.7	27.0	29.2	28.2
Lower leaf	11.9	23.8	17.0	15.0	23.8	18.7	15.1	27.0	20.3
Upper leaf	11.6	23.8	17.0	12.6	23.1	17.5	13.3	28.4	19.8
Air temp. above plants	11.9	24.8	17.5	12.2	24.8	17.9	13.3	25.9	19.1

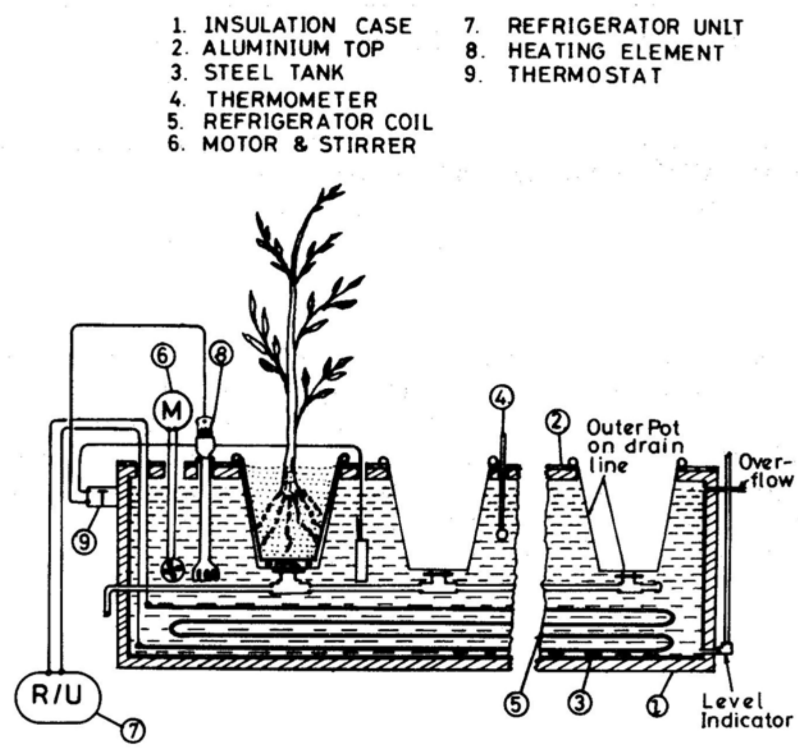
(Temperatures measured continuously by thermocouples, means compiled from 24 hourly readings. All conditions measured concurrently.)

A model was set-up in two phytotron cabinets to test the effects of climate in two seasons (1951 cf 1958) on fruit-set in sweet orange (Citrus sinensis). Actual meteorological temperature data over 10 weeks were reproduced using a tape-reader controller which also gave a slightly simplified diurnal change in temperature with the maximum and minimum air temperatures similar to ones as they occurred in the field. This control system was described by TRICKETT and MOSS (In Phytotronique et prospective horticole phytotronique II. Paris, Gauthier Villars, 72-8).

This experiment was intended to test the hypothesis that low yields following the 1951 Spring, and better than average yields following the 1958 Spring resulted from the temperature patterns effecting fruit-set. That is, cool conditions in Spring followed by hot weather had an adverse effect compared to warm conditions proceeding hot summer conditions. Although initially there was a difference between the two treatments in terms of fruits set little difference was found at the end of the experiment. Root temperature was not controlled.

Later experiments indicated an effect of root temperature - fuit-set declining sharply with increasing root temperature (over the range 17-25°C). So, to test our hypothesis, root temperatures should have been controlled to some extent, since a few days of high temperature (c 30°C max) would probably have had a greater effect through raised root temperature than through raised shoot temperature. In subsequent studies a root temperature control unit was used.

How one controls the temperature of the root medium depends on the system of cultivation. For hydroponics the medium can be circulated through a temperature control bath. However, we preferred sand culture for our plants. The most satisfactory equipment has consisted of a series of plastic plant containers connected and sealed to a central drainage tube, the plant in a similar container fits neatly inside this and the whole structure is surrounded by water in a tank. These containers are supported from the top of the tank. The size of the tank depends upon the type of phytotron cabinet to be used. In our artificially lighted cabinets these tanks need to be half the size of the floor space so that air circulation can occur (our cabinets have floor and wall vents). In controlled temperature glasshouses the tanks can be larger, but made to fit the design module and mounted on wheels. The outer plastic container and the top of the tank can be changed to provide for different sizes of plant container (Fig, 1).



Sufficient heat is supplied by a 2 kw immersible coil, and refrigeration by immersing cooling coils from a refrigeration unit (I/3 hp will often be sufficient capacity) mounted beneath the tank or outside the phytotron cabinet. The type of thermostat depends upon how closely controlled the temperature needs to be. If it is intended to be always below or above ambient air temperature then a simple thermostat will be sufficient with only heating or refrigeration being supplied as the case may be. Because of the large thermal mass of the water close control can be obtained easily provided water in the tank is circulated well by an efficient stirrer. The thermostat was positioned in the water, but the temperature of the root medium was constantly monitored.

An important consideration is insulation. The tank is covered with 25 mm foam polystyrene, while the top is insulated with 25 mm polystyrene covered by 2 mm sheet aluminium (vertical supports were provided).

It is important to protect the equipment against corrosion which is surprisingly voracious because of spilt nutrient solution, different metals in the bath, and earth leakage from electrical equipment. Steel parts should be galvanized and painted with zinc rich paint or bituminous paint (since the plants do not come into contact with the tank, heavy metal contamination is not a consideration). Fibre washers on bolts, plastic parts where possible, and insulation of copper pipes from other metals have proved satisfactory measures. The whole structure must be of adequate strength because a moderate sized unit (150 x 50 x 30 cm), in operation, may weight 400 kg.

Plants in this type of root temperature control unit were compared with ones in an open uninsulated water bath, and with plants on benches in the glasshouse. Thermocouple measurements were all made concurrently. Results are given in Table 1.

The open water bath resulted in higher leaf temperatures in the plants and surrounding air. Slightly higher temperatures in the lowest leaves were found when the insulated unit was used. However, in this experiment there was no forced air movement as in a phytotron cabinet, which would prevent the slightly higher leaf temperatures in the insulated bath. The open water bath, although much simpler in design would be unsuitable for work on flowering or morphogenic phenomena where night temperatures might be very critical.

Conclusion.

Root temperatures should be controlled in some types of phytotron experiments. This can be done with relatively simple equipment. The important factors are : position the plant pots in a water bath and provide drainage for the plants, adequate circulation of water for rapid response of the thermostat sensor, good insulation and circulation of air around the plants to prevent root temperature modifying the air temperature, and good basic design to prevent corrosion and structural failure.

IX - USE OF GROWTH ROOMS IN CASSAVA RESEARCH

(L. A. HUNT, **J. D. MAHON** and S. B. LOWE - Department of Crop Science, University of Guelph, Guelph, Ontario N1G 2W1, Canada).

Cassava (Manihot esculenta Crantz) is an important subsistance crop of low income families in the humid tropics. It is a perennial shrub, generally ranging in height from 1 to 5 m or more, with a number of enlarged storage roots. The yield of these storage roots, which constitute the consumable part, generally lies in the region of 10 tonnes/ha, but can reach 70 to 80 tonnes/ha. Until recently, the crop was neglected by research workers despite its importance as a food crop, and despite the apparent potential for improvement reflected in the difference between average and maximum yields. Recently, however, two International Agricultural Research Institutes have begun concentrated crop improvement programmes with cassava. One of these institutes is the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, and the other is the International Inst. of Tropical Agr. (ITTA) in Nigeria. In addition, several institutes within the temperate regions have undertaken contract research programmes with cassava.

Early in the formulation and assessment of recent cassava research efforts it became clear that a number of questions concerning cassava physiology needed to be answered before it would be possible to analyze production systems on the basis of an understanding of the plant's behavior. Equally, it became clear that the answer to some of the posed questions could most readily be obtained **by** application of the phytotron method, and by application of techniques that are not currently available in areas where cassava is field grown, but that could be applied if cassava could be successfully grown indoors. Some such questions concerned the effects of temperature on various specific growth characteristics, the effects of day-night temperature variations and air-soil temperature differentials on growth and development, the photosynthetic activity of individual leaves, and the respiration losses from stems and storage roots during the bulking period.

The growing of cassava in phytotron facilities presents a number of unique problems - the plant is large, the yield product is a storage root, and the growth cycle is extended over at least 10 months. In many countries, current growth facilities are simply not large enough to handle such problems. At Guelph, however, growth rooms large enough for work with tall tropical species are available, and these together with growth chambers have been used in a 2 year co-operative research project in which the indoor work has been linked with field **studies at** CIAT, Colombia. During the course of the programme, it has been shown that long duration and tall growing plants such as cassava can be successfully grown in indoor facilities. Results have indicated that dry matter and leaf area accumulation curves for the indoor plants were similar to field material, **and that** some of the more specific growth characteristics were the same in both conditions. The findings are thus encouraging for the potential use of phytotron facilities in investigations designed to sort out some of the more intractable environmental physiology problems. In addition, the findings suggest that indoor facilities could be used to supply material for laboratory analysis when it is impossible to undertake the appropriate analysis in a tropical region using field grown material, and when a clear definition of the pre-treatment environment is necessary before analysis. The present letter describes our growth procedures, and compares the indoor plants with field grown material.

Growth facilities and procedures.

The growth rooms available in the Department of Crop Science have been described elsewhere (STOSKOPF et al. , 1970) and only a brief description will be provided here. The rooms measure 8.7 x 13. 9 m, and the distance from the floor to the highest light canopy position is 3.1 m. The plant beds are 1. 8 x 7.3 m and can be raised or lowered to within 0.2 m of the room floor. When lowered, 90 1 boxes can be placed at the bottom of the plant beds to give a maximum distance between support and light of approximately 4 m.

Lighting is provided by cool white VHO reflectorized fluorescent lamps spaced at 12 cm intervals plus incandescent lamps (30 % of wattage). The fluorescent lamps are 2. 4 m long and produce nearly uniform lighting conditions across the plant beds. Attenuation of light with distance from the source is not marked when all light banks are at the same level, with the decline being approximately 10 % per meter. With a replacement interval of 1 year the irradiance at 1 m from the light bank is 450 p.E $m^{-2}sec^{-1}$ (400-700 nm).

The cassava plants were grown from 4-node cuttings in silica sand in large 40 cm x 40 cm x 60 cm plywood boxes in the rooms and in 30 cm fibre pots in the chambers. The silica sand was chosen because it permits easy extraction of roots and ready characterization of the moisture and nutrient status of the root environment. Principal particle size was between 0. 5 and 1. 0 mm and bulk density 1. 2 g cm^{-3}. The medium was flushed once or twice (younger room material and all chamber plants) daily with between 2 and 3 1 of nutrient solution based on 1/10 strength Hoagland's number 2 formulation. The plant boxes weighed approximately 120 kg when full, and were moved when necessary by a moveable crane which straddled the plant beds.

Field material was grown on the experimental farm at CIAT, Colombia. The latitude at the farm site is 3°32'N, and the mean temperature is 24°C (30°C daily maximum and 18°C daily minimum). The soils are fertile alluvial clays of good depth and medium water holding capacity. No fertilizer was applied.

Comparison of growth.

The indoor material was at all times lighter and carried a smaller leaf area than field grown plants (Table 1). The room plants were grown at a higher density than those in the field (4. 0-5. 5 cf 0. 25 plants/m^2). It may, therefore, partly reflect different degrees of inter-plant competition. The patterns of increase and decrease in leaf area were similar for the indoor and field grown material.

The harvest index (storage root weight/total plant weight) of the room material at 240 days was between 40 % and 45 %, a value which compares very favorably with values of 45 % to 55 % measured in many studies with LLANERA in the field at CIAT (see CIAT Annual Report for 1973).

The net assimilation rates (dry matter accumulated per unit of leaf surface area) were lower for the indoor plants (Table 2). The field and room data appear to belong to one leaf area index - net assimilation rate response curve of the form reported for many other species (see WATSON, 1958). It appears likely, therefore, that the difference between the indoor and field plants partly reflects the greater degree of mutual shading between leaves in the indoor plants. Plants were grown at a higher density in the rooms for space economy reasons.

Table I - Growth data for field (30/18 C), room (29/24 C) and chamber (27/22 C) grown cassava (cv. Llanera).

Age (days)	Leaf area (m^2/plant)			Total dry weight (kg/plant)		
Population	field	room	chamber	field	room	chamber
(plants m^{-2})	(0. 25)	(4. 0)	(5. 5)	(0. 25)	(4. 0)	(5. 5)
80	0. 2	0. 2	0. 2	0. 1	0. 05	0. 02
120	1.7	0.6	0.4	0.4	0.14	0.08
160	3.3	1. 3		1. 1	0. 3	
200	2. 9	1. 6		2. 1	0, 5	
240	1.8	1.6		1.9	0.9	

Table 2 - Net assimilation rates of field (30/18 C), room (29/24 C) and chamber (27/22 C) grown cassava (cv, Llanera),

Leaf area index (m^2 m^{-2})	Age (days)	Growth conditions	Net assimilation rates g m^{-2} day^{-1}
0.2	80 - 120	field	7.9
0.6	120 - 160	field	7.5
1.2	80 - 120	chamber	6.3
1.6	80 - 120	room	6.3
4. 2	120 - 160	room	4.8

The rates of leaf appearance for the room and field plants were quite similar for much of the growth cycle, with a wide divergence only appearing with the older material (Table 3), when the field plants suffered a severe water shortage. The temperature environment of field and room were quite similar and the findings presumably reflect the fact that rate of leaf appearance is controlled primarily by temperature.

Table 3 - Rates of leaf appearance for field (30/18 C) and room (29/24 C) grown cassava (cv. Llanera).

Age (months)	Rate of leaf appearance (leaves/10 days)	
	field	room
3	4.6	3.6
5	5.2	5,1
7	4. 2	4. 1
9	1. 9	3. 7

Conclusions.

The data demonstrate that cassava can be successfully grown over a complete production cycle in controlled environment facilities, and indicate that these latter could become useful tools for cassava research. It is not suggested that controlled environment facilities be constructed in tropical areas where field cassava *research* is being undertaken, but that co-operative programs be fostered whereby institutes with appropriate phytotron facilities be linked with institutes undertaking field research.

Such arrangements could make maximum use of the facilities and expertise available. An example of such co-operation is the current Crop Science Department, Guelph - CIAT, Cali program, under which the work reported here was undertaken.

Naturally, further development work is necessary to proceed to the stage where exact duplicates of field material can be grown in indoor facilities - attention to maximum light intensities and to nutrition may be particularly important in this regard. However, the results are sufficiently encouraging to suggest that controlled environment facilities could immediately become useful tools for research with cassava, and perhaps also other tall stature, long duration tropical crops.

Acknowledgement.

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X - USE OF CONTROLLED-ENVIRONMENT FACILITIES AS AN ADJUNCT TO FIELD RESEARCH ON POTENTIALLY TROPIC-ADAPTED GRAIN LEGUMES.

(R. J. SUMMER FIELD, A. H. BUNTING and E. H. ROBERTS - University of Reading, Department of Agriculture and Horticulture, Plant Environment Laboratory, Shinfield Grange, Shinfield, Reading RG2 9AD, Berkshire, U.K.)

This is a brief general report on the way in which controlled environment facilities - growth cabinets, glasshouses and plastic houses - are being deployed at Reading in a co-operative research project with the International Institute of Tropical Agriculture, Ibadan, Nigeria (IITA). The work sponsored by the U.K. Ministry for Overseas Development. It involves studies of the effects of variations, within the tropical range, in daylength and in day and night temperature on the growth and reproductive development of cultivars of grain legumes which may be adapted to tropical environments. The inter-relationships between applied mineral nitrogen and symbiotic nitrogen fixation are also being investigated. Wherever possible, the effects of two or more factors at two or more levels are investigated simultaneous ly, in factorial combinations, so that interactions as well as main effects can be measured.

Background.

Soybeans, which have not previously been grown to any extent in the tropics, and cowpeas, which are grown extensively in the tropics of Africa and Asia, and in parts of South America, could be used to increase substantially the output of plant protein in the wet tropics. Though in many tropical areas the indigenous population is not accustomed to the special methods of preparation of soybean which are used in the Far East to render it palatable and digestible, this could be overcome. Moreover, there is an expanding world market for soybean meal. The cowpea is an ancient crop but is still relatively undeveloped. In experiments, seed yields at least 10 times greater than those usual in traditional farming systems can be obtained.

Selection and breeding programs, together with agronomic, entomological pathological and physiological investigations on both species, and on other grain legumes, are being carried out in the field at IITA and elsewhere. The work outlined in this note is designed to assist, and perhaps to accelerate, the field program by providing information about the general physiology of these crops and the effects of environmental factors on growth and reproduction.

To screen cultivars for local adaptation in the field is tedious because variation between seasons in weather lead to substantial variations in growth and seed yield. Quantitative information, from work in controlled environments, on the main effects and interactions of environmental factors can, for example, assist the plant breeder (a) to identify immediately cultivars whose seed yields are not only potentially large but are also little affected by differences in climate and (b) to know, in quantitative detail, the effects of variation in weather and climate on the most promising breeding lines.

The collaborative research has been carried out at three levels of environmental control. The more detailed, quantitative aspects of the work, requiring the most precise control, have been undertaken on single, preferred cultivars of each species. The results of such studies enable us to explore the responses of a much wider range of cultivars to those environmental factors which are found to be of greatest importance, *using* facilities in which the environment is less completely controlled.

We now know, both generally and specifically, how dry matter and nitrogen are distributed during growth and development in various plant types of soybean and cowpea, and how this pattern is affected by climatic variables and by extreme combinations of some of them. We expect that this sort of information will help to identify the main attributes which distinguish plant types with various inbuilt growth strategies. We can also interpret rationally the effects of variation in climate and weather, between and within seasons, on growth and seed yield, over the range of variation characteristic of humid tropical environments - for which quantitative information of this sort is markedly lacking.

Facilities.

Our facilities are of three main sorts :

a Eight "Saxcil" growth cabinets (floor area 1. 8 m^2 ; height 1.2 m) in which daylength, day/night temperatures, relative humidity, light intensity and quality, and atmospheric composition can be precisely controlled and varied over time.

b - Four glasshouse compartments (floor area 27.6 m^2 ; height 5 m), each with two trolleys, and corresponding night-time "garages" (floor area 7 m^2; height 2 m), in which daylength and day/night temperatures can be controlled and night-break illumination provided.

c Two heated, plastic film houses (floor area 188 m^2 ; height 3 m) in which it is possible, during the six summer months, to simulate the environment of the wet tropics in all respects but daylength.

Main results.

Initially, it was essential to discover two things :

1 - What number and duration of short days (within the range of daylengths characteristic of the humid tropics) are required to induce flowering in the particular selections of soybean and cowpea identified as of interest to IITA ; and

2 - Whether we could not only grow these two species to maturity in controlled environments but also produce plants which resembled closely plants of the same cultivars grown in the field at Ibadan.

The first problem was examined in two series of experiments in which selected cultivars of soybean and cowpea were given varying periods of short-day induction treatment in the controlled daylength glasshouse and then grown on either in those conditions or in natural long days. We learnt that it is not possible to accelerate a screening program under temperature daylength conditions because, unless cultivars are kept in short days for at least 7 weeks, their subsequent reproductive ontogeny is adversely affected in long days.

To resolve the second problem, plant husbandry and management techniques such as variation in light quality, growing media, pot size, and irrigation requirements were investigated in more than 40 trials. The results established methods for cultural practices which have since enabled us to grow successfully all the cultivars of both species in which IITA has been interested. We believe that these findings will be useful in other research laboratories in which either legume is grown for experimental purposes under artificial conditions. They are summarized briefly in Table 1.

Table 1 - Combinations of suitable requirements for growing various legumes in controlled environment growth cabinets.

cultural aspect	cowpea	soybean	pigeon pea	lima bean
light quality*	daylight + 5 % T	daylight	warm-white + 10 % T	warm -white
pot size	18-30 cm diameter, perforated at the base, terra-cotta (unglazed)			
rooting medium**-	V/S/G ra 2:2:2 by volume : loamless compost® 9:1 V/V			
nutrient solution	Standard Long Ashton with 25 ppm N for nodulated plants and 200 ppm N for non-nodulated ones			
R *hizobium*	Appropriate single strain only ; surface sterilized seed stocks prior to re-inoculation			

* Fluorescent tubes giving a light intensity at pot level of c. 130 J m^{-2} sec^{-1} ± tungsten supplement (% calculated on nominal lamp wattage).

** V/S/G = vermiculite (grade size DM), sand (coarse and washed) and graved (0. 6 m crushed), respectively.

Experiments in growth cabinets.

We have investigated the effects of daylength, day and night temperatures and nitrogen nutrition on vegetative growth and reproductive development of both soybean and cowpea. In all experiments, night temperature has had very important effects - not only on overall growth and development but also on the various components of seed yield. With some cultivars, an increase in night temperature of no more than 5°C (from 19°C to 24°C), maintained throughout the life of the plant, can halve the time to first flowering - an effect considerably greater than that brought about by a change of 100 minutes in daylength. Day temperature becomes of major importance only after flowering, when warmer (33°C) as compared with cooler (27°C) day temperatures markedly decrease the seed yield of both legumes (from 58 g to 28 g per plant in soybean, and 83 g to 41 g per plant in cowpea) by affecting pod set in soybean and both the rate of leaf senescence and pod set in cowpea.

Because the effects of these relatively small changes in any one environmental factor are so large, these results have important consequences in the field, particularly for plant breeding. The screening of cultivars suitable for use in the IITA breeding program which give relatively large yields but are as invariant as possible under the range of variations in climate and weather likely to be encountered in the wet tropics is now a feature of the program. This is carried out in the automatic daylength-controlled glasshouse.

Experiments in the automatic daylength-controlled glasshouse.

In 1972, 15 soybean and 17 cowpea cultivars were screened to determine to what extent they were affected by variations in daylength and night temperature. In 1973 a further 45 cowpea cultivars, and in 1974, 22 cowpea cultivars and 8 pigeon pea selections were studied. Cultivars of all four possible physiological types were identified in each of the three legume species :

	Sensitive to: daylength	Sensitive to: night temperature
1)	+	+
2)	+	-
3)	-	+
4)	-	-

Selected cultivars of cowpea from each of the four groups above have now been used as parent lines at IITA. During 1975 we shall screen the progeny from these crosses in order to investigate how sensitivity to daylength and night temperature are inherited.

It also follows, from our results, that it is not possible, in the field, to test the effects of daylength during the growing season on time to flowering in tropic-adapted cultivars of grain legumes (for example by sowing at different dates), unless the effects of temperature can be studied simultaneously (for example by initiating experiments at several different altitudes). Our results have clarified anomalies which have arisen, particularly with soybean, from field trials where this essential prerequisite has not been met.

Experiments in the plastic houses.

The daylength-insensitive cultivars so identified have been used in experiments carried out in the plastic houses, which have concentrated, in the main, on the nitrogen nutrition of cowpea. The experiments have complemented those in the field at IITA in demonstrating that water shortage before flowering is particularly detrimental to vegetative growth and seed yield, that shading is less important and that successful and effective nodulation is critically important,

A number of experiments have been carried out in co-operation with P. J. DART (Rothamsted) on the effects on growth and seed yield in cowpeas of :

1 Various concentrations of combined nitrogen in nutrient solution given, throughout growth, to both nodulated and non-nodulated plants.

2 Short-term changes in the concentration at which combined nitrogen in nutrient solution is given to both nodulated and non-nodulated plants.

3 Small doses of combined nitrogen incorporated into the growing medium at sowing ("starter" nitrogen).

4 The distribution within the plant of combined nitrogen given in nutrient solution either before or after flowering.

5 Interaction between strains of Rhizobium and cultivars of cowpea.

6 The effects of waterlogging at various stages of growth and interactions between waterlogging and the level of combined nitrogen in nutrient solution given to both nodulated and non-nodulated plants.

In experiments 3 and 4, ^{15}N labelled nitrogen was used as a tracer, enabling us to discover when, and from where, nitrogen is accumulated in the seed.

These experiments show that to obtain satisfactory seed yields in cowpea, nodulation must be effective and symbiotic nitrogen must be fixed over a long time. In experiment 2 (above) the seed yield of nodulated plants (100 g per plant) was, overall, nearly double that of non-nodulated ones (56 g per plant). Supplying up to 60 ppm N of combined nitrogen from emergence to first-flower, from first flower to mid pod-fill or from mid pod-fill to maturity in no way compensated for the absence of nodules. It has proved impossible to increase significantly the seed yield of cowpea, above that obtained from nodulated plants receiving a very low level of combining nitrogen, by direct application of nitrate-N (up to a level roughly equivalent to 480 kg N ha^{-1}). Indeed, nodulated plants grown without any combined **nittio** yielded only 10 % less seed than non-nodulated ones supplied with 240 ppm N throughout growth.

Prospect.

The work outlined above has been mainly on cowpea and, to a lesser extent, on soybean. However, our colleagues at IITA believe that many more legumes may be valuable sources of plant protein in the humid tropics. Of these perhaps the most important are Pigeon pea (*Cajanus cajan*), Lima bean (*Phaseolus lunatus*), Yam bean (*Sphenostylis stenocarpa*) and Wing bean (*Psophocarpus tetragonolobus*).

The effects of environmental variation on growth, flowering and seed yield are even less well known in these species than in soyabean or cowpea.

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HUXLEY, P.A. , SUMMERFIELD, R. J. and the late A. P. HUGHES, 1975. Growth and development of soyabean cv. TK5 as affected by tropical daylengths, day/night temperatures and nitrogen nutrition. Ann. App. Biol. (in press).

XI - SOIL MOISTURE CONTROL FOR PHYTOTRONIC STUDIES

(Dr. L. Art SPOMER, Assistant Professor of Plant. Physiology in Horticulture, University of Illinois, Urbana, U. 61801 U, S. A,).

Plants contain and require more water than any other nutrient. Probably every growth function is affected either directly or indirectly by the status of plant water which depends primarily on the balance between water absorption from the soil and transpiration into the atmosphere, Adequate phytotronic techniques have been developed for control of transpiration ; however, relatively little consideration has been afforded the control of soil water supply. This letter briefly reviews a method for phytotronic control of soil moisture presently being developed at the University of Illinois.

Plants in phytotronic studies are grown almost exclusively in small containers. o4 soil or other growth media. The soil in such containers is distinguished from that same soil in a ground bed by two important characteristics : (A) it is small and (B) it is shallow. The effect of smallness on plant growth (reduced water and mineral storage) (1, 2) is obvious ; however, the effect of shallowness (excess soil water retention) (3) is less obvious but, when considered with the effects of soil physical amendment (4), suggests a simple method for the experimental control of container soil water supply.

In any soil, the pressure potential (measured with tensiometer) of the water contained in that soil is 0 at the level of a water table in that soil and decreases exactly proportional to height above the water table (3). This decrease in pressure potential means that at the water table level, the soil will be saturated and water content will also decrease with height above the water table as predicted by the water retention isotherm (moisture characteristic) for that soil. A water table can be formed by standing the soil in water or, in the case of free-draining container soils, a perched water table forms at the drainage level (bottom) following irrigation and drainage (3).

The pattern of water distribution above a water table depends on the pore size distribution in the soil which, in turn, depends on the texture and structure of the soil. A soil with predominately small pores will remain saturated for a considerable distance above the water table, a soil with predominately large pores may be essentially dry only a short distance above the water table, and a soil with a wide range of pore sizes will continually decrease in water content above the water table. With this in mind, it should be possible to control water content in soil containers by using soil mixtures containing different proportions of small pores (remain saturated) and large pores (drained just above water table) thereby controlling the volume of water retained in the soil (or controlling the degree of aeration in the soil). This possibility has been partially confirmed with the recent development of a model of soil physical amendment which can be used to predict total porosity, water retention porosity, and aeration porosity in any combination of soil and coarse-textured amendment (4). Further development of this model to include container depth, amendment type and amendment texture is presently under way at the University of Illinois and should be at the application stage by late 1975.

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3. SPOMER, L. A. , 1974 - Two classroom exercises demonstrating the pattern of container soil water distribution. Hort. Science 9(2) : 152-153.

4, SPOMER, L. A, 1974 - Optimizing container soil amendment : the threshold proportion and prediction of porosity. Hort. Science 9(6) : 532-533.

XII - NEWS FOR PHYTOTRONISTS

A New books.

The following technical papers have been issued by the ISM. (Secretariat : Dr. G. de BAKKER - 1 ev. d. Boschstraat 4, The Hague, The Netherlands),

n° 37 Symposium on Artificial Media in Horticulture. Ghent, 1973 - published in June 1974, 167 p.

n° 38 Symposium on Vegetable Storage. Weihenstephan, 1973 - published in June 1974. Vol, 1, 350 p ; vol. 2, 256 p.

n° 40 3rd Symposium on Horticultural Economics. Wageningen, September 1972 - published in November 1974. Vol. I and II, 563 p.

n° 41 Symposium on Post-Harvest Physiology of Cutflowers. Littlehampton, October 1973 - published in January 1975. 272 p.

n° 42 Symposium on Cultivation of Vegetables in the Mediterranean Regions. Avignon, 1973 - published in June 1974. 380 p.

n° 43 Symposium on Cultivation of Flowers under Protection in the Mediterranean Regions, Barcelona, April 1973 - published in September 1974. Vol, I, 207 p ; vol. II, 220 p.

n° 45 Symposium on Bitter Pit in apples. Bonn, May 1974 - published in November 1974. 75 **p.**

n° 46 Symposium on Greenhouse Design and Environment. Silsoe, September 1973 - published in April 1975. 227 p.

- Biological Action of Ultraviolet Radiation. (In Russian). Ac. Sc. USSR. Ed. NAUKA. Moscow 1975, 280 p.
- Genetic Aspects of Photosynthesis. Yu. S. NASYROV and Z. SESTAK selected papers from the symposium held on October 17-24, 1972 in Dushanbe, USSR. Dr. W. JUNK B. V. Publishers, The Hague, 1975, 384 p.
- Environmental and Biological Control of Photosynthesis. R. MARCELLE. Dr. W. JUNK B. V. Publishers, The Hague 1975, 408 p.

Vegetation and Environment. B. R. STRAIN and W. D. BILLINGS. Dr. W. JUNK B. V. Publishers, The Hague 1974, 194 p.

Lecture Notes in Physics. Vol. 12. Statistical Models and Turbulence. Ed. M. ROSENBLATT, C. Van ATTA. Springer Verlag New York Berlin, Heidelberg 1975, 492 p.

Developpement et Environnement. Albert SASSON. Editions Mouton (7, rue Dupuytren - 75006 Paris). 1974, 423 p. 64 francs.

- Bulletin of Applied Botany, Genetics and Plant Breeding (seed testing). Vol. 51, fasc. 2, 1974 Leningrad.
- Form, structure and function in Plants. Prof. B. N. JOHRI Commemoration volume. Editor Sarita PRAKASHAN, Meerut, UP. India, 1975, 440 p.

Multivariate analysis in vegetation research. Laszlo ORLOCI. Dr. W. JUNK B. V. Publishers, The Hague 1975, 276 p.

B - New Scientific Reviews.

Ecological Modeling.

The following subjects are included : Uses of mathematical models. System analyzes to describe ecosystems, to control pollution of the environment and for resources cultivation.

Subscription ; The Elsevier Scientific Publishing Co. , P. O. Box 211, Amsterdam (The Netherlands).

C - Articles in print.

BIERHUIZEN J. F. - Root growth and its environment. Acta Horticulturae n° 39, 1974, 127-140.

HOPMANS P. A. M . - Measurement of plant water status of greenhouse crops with pressure bomb and p-gauge. Acta Horticulturae n° 35, 1974, 113-122.

BIERHUIZEN J. F. and WAGENVOORT W.A. - Some aspects of seed germination in vegetables. Scientia Horticulturae, 2, 1974, 213-219.

BAJAJ Y. P. S. - Potentials of protoplast culture work in agriculture. Euphytica, 23, 1974, 633-649.

ABDELHAFEEZ A. T. , HARSSEMA H. and VERKERK K. - Effects of air temperature, soil temperature and soil moisture on growth and development of tomato itself and grafted on its own and egg-plant rootstock. Scientia Horticulturae, 3, 1975, 65-73.

DOORENBOS & CARPER J. J. - X-ray induced mutations in Begonia X Hiemalis. Euphytica, 24, 1975, 13-19.

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KATO K. - Outline of Japan's greenhouse horticulture. Plasticulture, n° 22, 1974, 25-28.

de VILLELE 0. - Influence of the external climate on the growing conditions in greenhouses. Plasticulture, n° 23, 1974, 5-12.

MURFET I. C. and REID J. B. - Flowering in Pisum : the influence of photoperiod and vernalising temperatures on the expression of genes Lf and Sn. Z. Pflanzenphysiol. , 71, S. 323-331, 1974.

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ALBERTE R. S. , HESKETH J. D. , HOFSTRA G. , THORNBER J. P. , NAYLOR A. W. , BERNARD R. L. , BRIM C. , ENDRIZZI J. and KOHEL R. J. - Composition and activity of the photosynthetic apparatus in temperature-sensitive mutants of higher plants. Proc. Nat. Acad. Sci. USA, 71, n° 6, June 1974, 2414-2418.

BILLINGS W. D. - Adaptations and origins of alpine plants. Arctic and Alpine Research, 6, n° 2, 1974, 129-142.

BOURQUE Don P. and NAYLOR Aubrey W. - Homologies between higher plant and algal 25S cytoplasmic ribosomal RNA. Life Sciences, 14, 1974,-427-1241.

DA SILVA J. V. , NAYLOR A. W. and KRAMER P. J. - Some ultrastructural and enzymatic effects of water stress in cotton (Gossypium hirsutum L.) leaves. Proc. Nat. Acad. Sci. USA, 71, n° 8, 3243-3247, August 1974.

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LARSON R. A, and BONAMINIO V. P. - Application of A-Rest to Chrysanthemums growing in a bark medium. North Carolina Flower Growers Bulletin, vol. 17.

LARSON R. A. , LOVE J. W. and BONAMINIO V. **P. -** Relationship of potting mediums and growth regulators in height control. Florists Review, vol. 155.

D - Events, meetings and exhibitions planned.

1975 October 19-22, Sofia (Bulgaria).

II. Symposium on plant growth regulators.
Organized by M. POPOV, Institute of Plant Physiology, Academy of Sciences, Academy of Agricultural Sciences, Ministry of Agriculture and Food Industry and the Technical Scientific Union of Agriculturists.
Topics :

1. Regulation of plant growth and development - general problems.
2. Natural regulators.
3. Synthetic regulators.
4. Application of growth regulators.

A special Symposium review is envisaged to be published in Russian and English.

Inquiries : 2nd Symposium on Plant Growth Regulators - M. POPOV, Institute of Plant Physiology (36 street, block 6, Sofia 13, Bulgaria).

1975 November 12-19, Paris (France)
Permanent formation studies : seeds germination.
Inquiries : Centre de Perfectionnement INA (16, rue Claude Bernard - 75231 Paris).

1975 November 16-26, Kyoto (Japan).
International Congress of Scientists on the Human Environment.
Inquiries : Dr. Y. FAKUSHIMA, Science Council of Japan (22-34 Roppongi 7-chome, Minato-ku, Tokyo 106, Japan).

1975 November 17-20, West Berlin (FRG).
European Symposium on Juvenility in Woody Perennials.
Inquiries : Prof. A. KARNATZ, Inst. f. Nutzpflanzen f. Obst T. U. Berlin (Fachbereich 15, D-1000 Berlin Dahlem. albr., Thaerweg 3, FRG).

1975 November 28 - December 1, Ghent (Belgium).
Xth International Exhibition of horticultural technics.
Inquiries : Faire Internationale de Gand - Kortrijksesteenweg 640, 9000 Ghent (Belgium).

1975 December 12-17, New Delhi (India).
International Congress on Water Resources,

Inquiries : Central Board of Irrigation and Power, Kasurba Gandhi Marg, New Dehli, 11001 India.

1976 Switzerland,

Symposium on Labour and Labour Management.

Inquiries : Dr. A. WIRTH, Swiss Federal Res. Sta. for Arboriculture and Horticulture, 8820 Waedenswill, Switzerland.

1976 Alexandria (Egypt).

5th African Horticultural Symposium.

Inquiries : H. D. TINDALL, Nat. College of Agr. Engineering Silsoe Bedford (U. K.).

1976 Quebec (Canada).

International Floralies of Quebec.

Inquiries : Organizing Committee, 2527 Gregg. Str. , Sainte Foy, Quebec, Canada 61 W1 J5.

1976 January 12-15, Paris (France).

Permanent formation studies : Vegetative propagation of plants.
Inquiries : Centre de Perfectionnement INA (16, rue Claude Bernard, 75231 Paris).

1976 February 8-14, Lima (Peru)

Symposium on Tropical and Subtropical Fruits. Program : breeding, minor species, propagation, crop physiology, cultural treatments, handling and marketing.

Inquiries : R. FRANCIOSI, Estacion Experimental Agraria, La Molina, Apartado 2791, Lima (Peru).

1976 Marsh - Melle (Belgium)

Symposium on Azaleas (ISHS and Eucarpia).
Inquiries : Prof. J. van ONSEM, Inst. of Ornamental Plant Growing, Caritasstraat 21, Melle 9230 (Belgium).

1976 April 9-13, Munich (RFA)

European Conference on Biochemical Analysis.

Inquiries : Dr. Rosemarie VOGEL, Nussbaumstr. 20, Box 200324, D-8000 Munchen 2, R. F. A.

1976 April 24-May 4, Genova (Italy)

Euroflora 76 - IIIrd International Exhibition of Horticulture.

Inquiries : Euroflora 76, Piazzole J, F. Kennedy 16129, Genova (Italy).

1976 May, Corsica (France)

Symposium on Problems of Citriculture in Mediterranean Countries (ISHS)

Inquiries : Dr. L. BLONDEL, St. Rech, Agr. San Giuliano par Mariani-Plage, Corsica (France).

1976 May, Bucharest (Rumania).

Symposium "Protected cultivation of tomato, pepper and egg-plant".
Inquiries : Prof. CEAUSESCU. Project ISHS.

1976 May 30 - June 2, Amsterdam (The Netherlands).

18th Congress International Seed Federation.
Inquiries : Organisatiebureau Amsterdam, N. V. Europaplein 14, Amsterdam (The Netherlands).

1976 July 26-30, Dundee (U.K.).

Symposium on Breeding of Rubus and Ribes and its relation to the the problems of mechanical harvesting (ISHS and Eucarpia).

Inquiries : Dr. D. L. JENNINGS, Scottish Horticultural Research Inst. , Invergowrie, Dundee, Scotland (U. K.).

1976 July, Hannover (FRG).
Symposium on cultures of Vaccinium Species (ISHS).
Inquiries : Prof. LIEBSTER, Inst. 1. Obstbau, T. U. Munchen 6050, Freising Weihenstephan (FRG),

1976 early August, Michigan (USA).
ISHS Symposium on ornamental and floriculture genetics and breeding.
Inquiries : Dr. Kenneth Sink, Dept. of Horticulture, Michigan State University, East Lansing, Michigan 48823, USA.

1976 August 1-8, Cali (Colombia).
IVth International Symposium on Tropical Root Crops.
General topics : all aspects of Tropical Root Crops. Organizer : International Society for Tropical Root Crops.
Inquiries : Dr. Eduardo ALVAREZ-LUNA, Centro Internacional de Agricultura Tropical, Apartado Aereo 67-13, Cali, Colombia (South America).

1976 August 9-18, Aas-Nlh (Norway) and A.lnarp (Sweden).
Symposium on growth and development of potplants (Norway) and roses (Sweden). (ISHS)
Inquiries : Prof. E. STROMME, Dept. of Floriculture, Box 13, Agric. College of Norway, N-1432 - Aas-NLH (Norway) and Prof. T. KRISTOFFERSEN, Dept. of Ornamental Horticulture, Agric. College of Sweden, S. 230. 53 Alnarp (Sweden).

1976 August-September, USA or The Netherlands.
3rd Symposium on vegetable storage.
Inquiries : Dr. J. APELAND, Dept. of Vegetable Crops, Agric. Univ, of Norway, Box 22, 1432 Aas-NLH (Norway).

1976 August 29-September 3, Rome (Italy).
7th International Congress on Photobiolo
There are 15th Symposia, among them : iotosynthesis, tiutagenic 'Effects of Radiation, Light and Development, Photomovement, etc.
Inquiries : Dr. A. CASTELLANI, CNEN-CSN, Casaccia, Casella Postale 2400 - 00100 Rome A. D. (Italy).

1976 August 30 - September 4, Lausanne (Switzerland)
IXth International meeting on growth substances.
Inquiries : Prof. P. E. PILET, Institut de Biologie et Physiologie vegetales de l'Universite, place de la Riponne, 1005 Lausanne (Switzerland).

1976 September 6-10, East Mailing (U.K.)
Symposium on High Density Plantings (ISHS).
Inquiries : Dr. J. E. JACKSON, Pomology Section E. M. R. S. East Mailing nr. Maidstone Kent (U. K.).

1976 September 19-25, Poznan (Poland).
5th International Peat Congress.
Topics : Peat and Peatlands in Protection of Natural Environment. In section 4 : new ideas on the utilization of peat in agriculture and horticulture.
Inquiries : Secretariat of Congress, ul. Wspolna 30, 00-930 Warszawa 71, Poland.

1976 September end, Pisa (Italy).

<u>ISHS Symposium on flower formation in ornamentals.</u>

Topics : Flower formation and control of flowering in plants cultivated as cut flowers, potted plants or flowering shrubs.

Inquiries : Prof. A. ALPI, Instituto di Orticoltura e Floricultura, Viale delle Piagge 23, 56100 Pisa (Italy).

1976 October 1-10, Florence (Italy).

Symposium on Pear Culture. (ISHS).

Inquiries : Prof. F. SCARAMUZZI, Inst. di Colt. Arboree, Fac. di Agraria, Via Donnizeit. 6, Florence 50144 (Italy).

1976 October/November, Las Palmas (Canary Islands).

4th International Congress on Culture.

Inquiries : International Working group on Soilless Culture (IWOSC), P. 0. Box 52, Wageningen (The Netherlands).

1977 Ghent (Belgium).

Symposium on Tissue Culture. (ISHS).

Inquiries : Prof. BOESMANS - Coupure Links 235, 9000 Ghent (Belgium).

1977 In the Netherlands, Sweden or USSR.

Symposium on more3rofits of the energy on greenhouses (ISHS).

Inquiries : G. H. GERMING - IMAG - Postbox 43, Wageningen (The Netherlands).

1977 Wellesbourne (U. K).

Symposium on Timing Field Production of Vegetables.

Inquiries : Dr. K. VERKERK, POB 30 Wageningen (The Netherlands).

1977 February, San Diego, California (USA).

7th International Colloquium on Plastics in Agriculture.

Inquiries : Mr. B. HALL, University of California, Agricultural Extension Service, 5555 Overland Ave. , San Diego, Calif. 92123 (USA).

1977 April, Antibes (France).

Symposium on Carnations (ISHS).

Inquiries : M. J. GARNAUD, 14 ay. Ste Marie, 94 Creteil (France).

1977 September, Nottingham (U. K).

ISHS Symposium on seed problems in horticulture.

General topics : 1 - Seed production ; 2 - Special germination problems ; 3 - Health and vigour ; 4 - Improvement of seed performance ; 5 - special features (storage, testing techniques, thermo gradient and other devices).

Inquiries : Dr. W. HEYDECKER, University of Nottingham, School of Agriculture and Horticulture, Sutton Bonington, Loughborough LE 12 - 5 RD, England, U. K.

1978 August 15-23, Sydney (Australia).

20th International Horticultural Congress.

Inquiries : Secretary of Congress, G. P. 0. Box 475, Sydney N. S. W. 2001 (Australia).

1982 Hambourg (F. R. G.)

21st International Horticultural Congress.

Inquiries : Prof. D. FRITZ, Institut fur Gemusebau 8050, Weihenstephan, Freising/OBB, Germany, Fed. Rep.