Secretariat Phytotronique
Phytotron C. N. R. S.
91 90- Gif-sur-Yvette
France

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PHYTOTRONIC NEWSLETTER N°16

Summary

Information and Various News

I- EDITORIAL

As we had forseen in the preceding issue we continue in this number to reproduce a series of articles and communications presented at the 1975 Botanical Congress, revised and brought up to date by their authors.

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We thank all those readers who write to us encouraging us in our endeavour and we are sorry that we are unable to answer these letters due to secretarial difficulties.

We also thank all those who send us benevolent financial support. We again ask that it be sent to us,with the endorsement : "Participation aux frail de parution de "Phytotronic Newsletter" and making cheques in the name of :

A l'ordre de l'Agent Comptable secondaire du CNRS,46me circonscription-
91190-Gif-sur-Yvette-France

Postal cheques and money orders in the name of :

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This issue comprises several chapters :

a) Meetings-Several meetings are noted under this chapter heading; we regret we are not able to publish more information, but in spite of our requests, we have received very Little news about scientific or technical meetings being organized in various countries, liable to interest our readers. Hopefully, our requests will elicit more response in the future....

b) Research strategy,articles and scientific papers. The major part of this issue is devoted to papers given at the Botanical Congress in Leningrad, as mentioned earlier. These articles are definitely of general interest, especially since two thirds of them have been edited by our Soviet colleagues whose work sometimes remain less well known.

c) Information and Various News. This last chapter in general is greatly appreciated by our readers, judging by the mail received. We ask our readers please not to forget to keep us informed about any organized events which they know will take place. We thank you in advance for your attention.

In closing we ask our readers to send us all documents, news ,technical papers or scientific articles on applied or fundamental research in plant physiology and horticulture which may be of interest to all "phytotronists".

Thanking you in advance

R. Jacques and N. De Bilderling

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II. ISHS SYMPOSIUM VEGETABLE CROPS UNDER GLASS PROTECTION

Bucharest 18-22 may 1976

ISHS Commission on protected cultivation report :

A symposium on "Vegetable crops under glass protection" was held in Bucharest,Roumania 18-22 may 1976, in cooperation with the Section for Vegetables. The symposium was organized under the responsahility of Prof. Dr. I. Ceausescu, Roumanian Minister of Agriculture and the Food Industry. The symposium was attended by about 200 participants from Roumania and 150 participants from other countries. More than 100 papers were, presented. Very interesting excursions were organized to glasshouse complexes in the regions of Bucharest,Brasov and Craiova.

Those who want more information please write to :

Secretariat of the ISHS Bezuidenhoutsewej 73-The Hague Netherlands

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III. IInd SYMPOSIUM ON ARABIDOPSIS RESEARCH I

Frankfurt/Main September 13-15 1976

Professor A. R. KRANZ has sent us volume 13 of the newsletter "Arabidopsis Information Service" which gives the proceedings of the Second International Symposium on Arabidopsis Research. The aim of this meeting was to assist the international research activities in this pilot plant, by personal contact and discussions in order to clear up the present problems of gene exploration, preservation and experimentation.

The lectures presented in this volume are divided into 8 parts :

1) Opening session: Retrospect and prospect of Arabidopsis research and international cooperation
2) Meeting 1: Conservation and organization of seed banks chairman A. R. KRANZ
3) Meeting 2: Genetical structure of populations-chairman K. NAPP ZINN
4) Meeting 3: Enzyme polymorphism- Chairman M. JACOBS
5) Meeting 4: Regulator mechanisms Chairman G. P. REDEI
6) Meeting 5: Genetics of photosynthesis Chairman P. D. USMANOV
7) Meeting 6: Morphogenesis and cytogenetics Chairman A. R. KRANZ
8) Meeting 1: Somatic cell Genetics Chairman A. CORCOS

Those who wish to have more information please write to : A I S Service Prof. Dr. A. R. KRANZ. Biology (Botany) University Siesmayerstt.70. D. 6000 Frankfurt/Main FRG.

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IV. ROOT STUDY GROUP SEMINAR

Grenoble 5-6 October 1976

For the fourth time since its creation in 1973 the group has met at Grenoble for a seminar; this time entitled "Mycorhizes and Morphogenesis". More than sixty participants were present .

A report of the proceedings is published,in French, in two parts comprising the introduction accounts and their discussion :

Volume 4. Part 1. by J. GAGNAIRE MICHARD and A. RIEDACKER

"Morphogenesis,Tropisms and Direction of Growth Mycorhizes and Morphogenesis" 136 pages.

"Morphogenesis, Tropisms and Direction of Growth" given by Professor P. NEVILLE (Universite d'Aix Marseille)

"Ectomycorhizes and Morphogenesis" given by Mme G. BRUCHET and G. GAY (Université Claude Bernard Lyon)

"Some consequences of the absence of a Meristem in Cuscutes"
Mr. A. FER (Universite Scientifique et Médicale de Grenoble).

Volume 4. Part 2. by A. RIEDACKER and J. GAGNAIRE MICHARD

"Mycorhizes and Morphogenesis:
Problem posed to nurserymen, horticulturists and foresters" 113 pages.

The ectomycorhizes

-(their role in the physiology of trees; their importance for the reforesting of marginal ecological zones) given by M. D. MOUSAIN (INRA Clermont-Ferrand)

-The influence of the inoculation by a defined fungus and of the mycorhization on the growth of forestry trees by Mc J. DELMAS,Mme Nicole POITOU , Mr. D. MOUSAIN (INRA)

- A brief description of problems encountered in practice by Mr. J. DELMAS (INRA Bordeaux)

-The role of mycorhization in mineral nutrition, the metabolism of nitrogen and the behaviour of resinous trees by Mr. F. LE TACON (CNRF Nancy)

-Practical application of mycorhizian Symbiosis by Mr. G. CHEVALIER (INRA Clermont Ferrand)

-Root Deformations by Mr. A. RIEDACKER (CNRF Nancy)

These reports as also those of preceding meetings of the root study group may be ordered from:

Madame J. GAGNAIRE MICHARD
Laboratoire de Biologie vegetale. Departemeht de Recherche Fondamentale
CEN Grenoble 85 X. 38041 Grenoble Cedex France

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V. PROBLEM ON ENERGY SAVING

ISHS Commission for Horticultural Engineering report in its 29th Newsletter of march 1977 p.4:

Energy saving

Energy saving in horticulture,especially for Protected Cultivation,has become an important topic to which several research projects are devoted. To all who are interested in this subject we mention again: the International Symposium on "More profitable use of energy in protected cultivation",organized by the Agricultural University of Sweden,August 22-26,1977 at Alnarp, Sweden.
Secretary: Dept. Floriculture and Ornamental Horticulture,Agricultural University of Sweden, S 230 53 Alnarp, Sweden.

In September 1976 in Karlsruhe a working party of about 20 Western European engineers and physicists was held also regarding the subject of energy saving. This working party was organized by the co-workers of the Institute for Horticultural Engineering of the Technical University of Hannover,Germany (prof. von Zabeltitz).

This meeting was sponsored by the EC (Commission of the European Communities at Brussels) and set up at the initiative of the Commission for Horticultural Engineering. This meeting which can be seen as a regional activity, consisted of a number of short lectures and ample discussions on the technical-physical aspects of energy saving in greenhouses. Papers and discussions are to be printed and it is hoped that they are available to the participants of the Alnarp Symposium . At this latter Symposium some papers will summarize the work at Karlsruhe.

During the meeting in Karlsruhe a Survey of technical- physical research projects in some W. European countries has been composed. This list is presumably not complete,but a start has been made and supplementary information is welcome. So we kindly request every reader to send us this information which may facilitate the mutual exchange of experience.

Please contact the Executive Vice Chairman of ISHS Commission for Horticultural Engineering : G. H. GERMING MAC Potstbox 43 Wageningen The Netherlands.

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VI. 20th HORTICULTURAL CONGRESS 1978. PHYTOTRON SYMPOSIUM

The revue ChronicaHorticulturae vol.17,n°2 June 1977 gives a lot of useful information concerning the 20th International Horticultural Congress due to be held in Sydney (Australia) from the 15th August to the 23rd August 1978 the following list indicates the excursions available before or after the congress to participants.

1) Tours in Australia (A to G)

Tour A. Fruits and Vegetables of the temperate region. Depart from Melbourne
Tour B. Citrus fruit and viticulture. Depart Adelaide
Tour C. General horticulture (South) Dept. Melbourne
Tour D. Tropical fruit. Depart. Brisbane
Tour E. Vegetables. Depart. Brisbane
Tour F. General Horticulture (north) Depart Brisbane
Tour G. Ornamental and indigeonous plants. Depart Perth.

2) Tours in New Zealand (Q to T)

Tour Q. Sub tropical fruit. Depart Auckland
Tour R. Fruit Vegetables and Viticulture. Depart Auckland
Tour S. Ornamental and indigeonous Plants. Depart Auckland
Tour T. Tourism in the southern island of New Zealand Depart. Christchurch.

3) Papua and New Guinea Tour U.

Papua and New Guinea Depart Port Moresby

The sections of the congress will be :

1. Interdisciplinary Section. President M . G. Mullins
2. Post harvesting horticulture. General Theme.20th Century Technology. President W R Mc GLASSON
3. Citrus Fruit. President P. R. CARRY
4. Viticulture. President B. G. COOBE
5. Temperate region fruit. President C. R. BROUGH
6. Tropical and sub tropical fruit. President H. M. GROSZMANN
7. Vegetables. General theme: Vegetables growing between the equator and the poles. President. W. J. GREENHALGH
8. Ornamental plants and ornamental horticulture. President W. R. WATSON

As indicated on pace 24 le Secretariat Phitotronique would like to organize at the centre of the Interdisciplinary Section a Symposium on PhYtotron Horticulture. persons who would like to present talks,reports,provoke discussions on a given subject are asked to make contact with the Secretariat Phytotronique. CNRS
91190-Gif-sur-Yvette France

For all other problems concerning the Horticultural Congress please write to:

Secretary of Congress
G P 0 Box 475 Sydney
N S W 2001 -Australia.

VII. FEEDBACK CONTROL OF LEAF TEMPERATURE I

Tsuyoshi Matsui and Hiromi Eguchi
Biotron, Institute,Kyushu University, Fukuoka, Japan

It is known that the leaf temperature is complicatedly affected by physiological functions and environmental factors even under the controlled environment in the phytotron or in the growth cabinet (1 to 6). For the exact control of the leaf temperature,it is necessary to develop a new system of the leaf temperature control. Present study *deals* with the leaf temperature control by means of the feedback system and also with the analyses of the characteristics.

Material and Methods

Plant material. Cucurbita maxima Duch "Tokyo-wase" was cultivated in charcoal of chaff which was used as the root supporter,and it was soaked to the water to give the moisture. The cotyledon of 5 days old seedling was used for this study.

Growth cabinet (7) . The capacity of electric heaters was regulated by PID action under continuous operation of the refrigerator with cooling capacity of 7,500 kcal,where the heating capacity was about 13,000 kcal at its maximum. In this growth cabinet,it is possible to control the air temperature of -5°C to 40°C with an accuracy of + 0.5 C and also to control the air humidity of 20% to 90% +/1 3% within

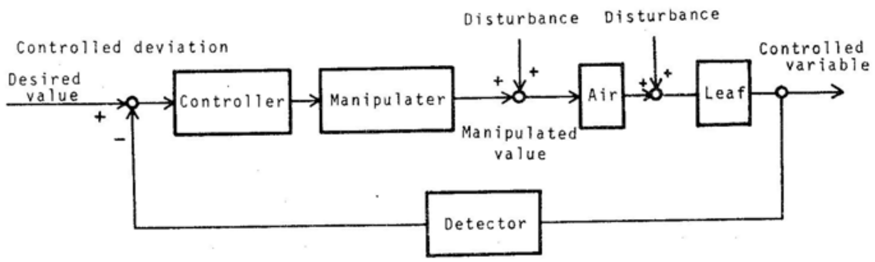


Fig.1. Block diagram of feedback control system of leaf temperature

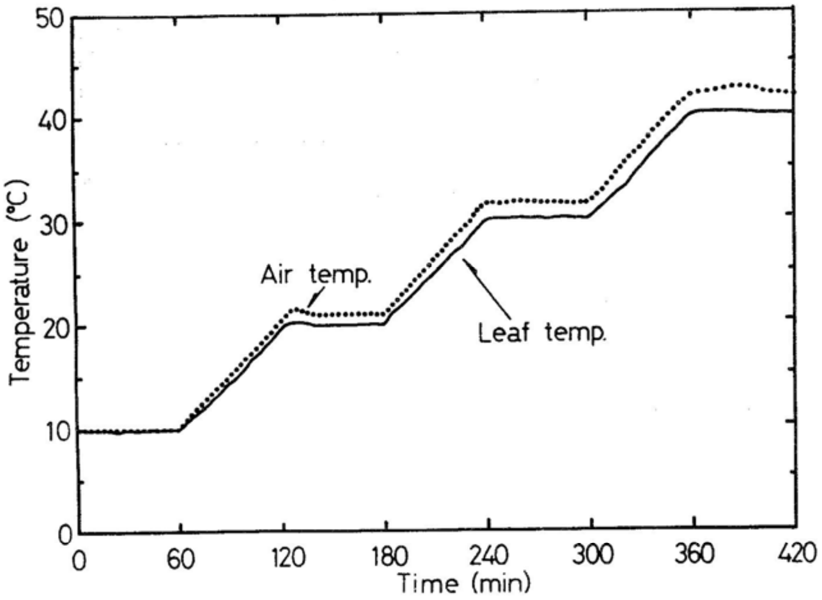
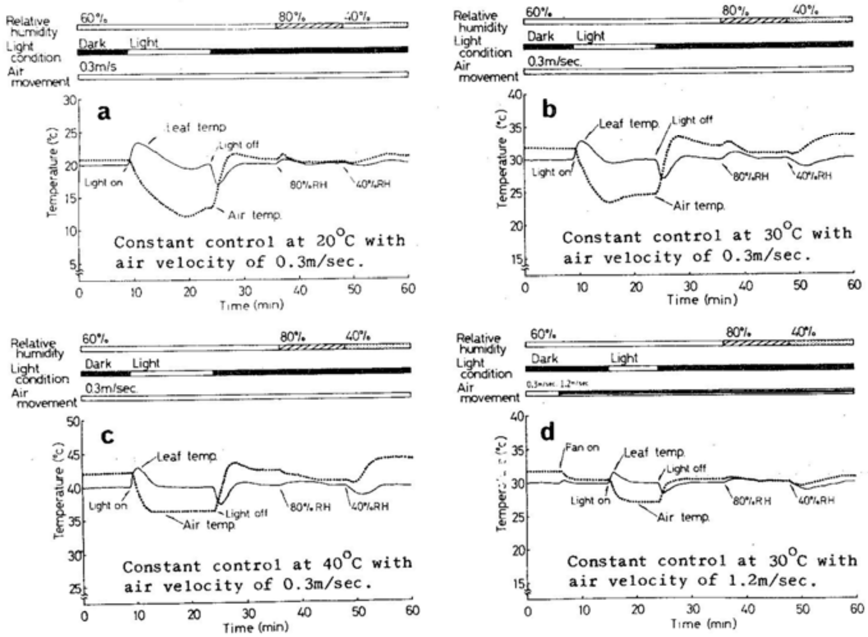


Fig.2.Ramp response in program control of leaf temperature under the relative humidity of 60% in darkness



a: Constant control at 20°C with air velocity of 0.3m/sec.

b: Constant control at 30°C with air velocity of 0.3m/sec.

c: Constant control at 40°C with air velocity of 0.3m/sec.

d: Constant control at 30°C with air velocity of 1.2m/sec.

Fig.3. Effect of environmental conditions on the feedback control of leaf temperature

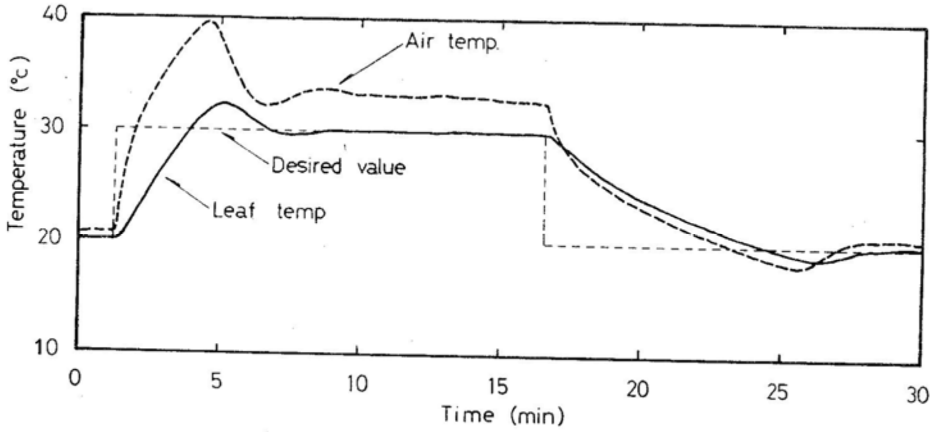


Fig.4. Step response in leaf temperature feedback control (RH=60%,air velocity = 0,3m/sec in darkness)

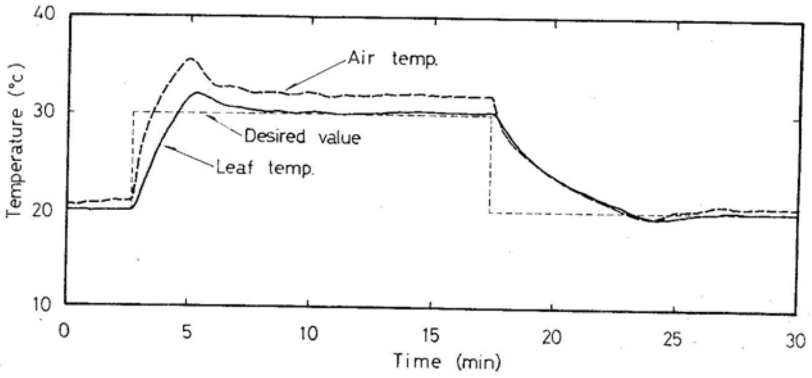


Fig.5. Step response in leaf temperature feedback control (RH=60% ;air velocity = 1,0m/sec in darkness)

temperature range of 10°C to 40°C. The lateral velocity of air movement was controlled by changing the rpm of a fan. For radiation to the leaf, an tugsten incandescent lamp was used.

Test procedure. Figure 1 shows the feedback system of leaf temperature control. The leaf temperature was detected by means of a microthermistor (Hypodermic probe, Y S I Co., USA) which was inserted into the cotyledon of the Cucurbita seedling. By this thermometer, the leaf temperature can be measured with an accuracy of + 0.3°C and a time constant of 0.6 sec. The detected signal of the leaf temperature was exchanged into voltage of 10 mV D. C. at 50°C and 0 mV D. C. at -10°C and was led into PID controller to use as the feedback signal. In this system, the air is used for heat transfer, and the leaf temperature can be controlled by setting the desired value in a program generator.

To analyze the response characteristics in the leaf temperature control, various conditions of light, air humidity and air movement velocity were given to the leaf temperature control.

Results and Discussion

Figure 2 shows a ramp response as an example in feedback control of the leaf temperature under 60% RH and air movement of 0.3 m/sec in darkness. The controlled leaf temperature well conformed to the desired value. At 10° C,there is no difference between air and leaf temperatures. With increased temperatures,the air temperature became higher than the leaf temperature.

Figure 3 shows the effects of changes of air movement, humidity and light radiation on the static controls of leaf temperature,in which, (a) (b) and (c) show the respective controlled valuables at 20,30 and 40°C, and (d) shows the effect of increased air movement on the control of leaf temperature at 30°C. When the leaf was irradiated vertically with the intensity of 31 mW/cm2 by an incandescent lamp,then the leaf temperature rose rapidly. On the other hand,the air temperature fell to compensate this rise of the leaf temperature, and gradually settled to the desired value. The effect of this radiation on the leaf temperature control was largest at 20°C and became smaller at higher temperatures. The settling time was about 15 min at its maximum. When radiation was stopped, the leaf temperature fell, and the air temperature rose. The leaf temperature was settled within about 6 min. When changing the air humidity from 80% to 40% the leaf temperature was affected distinctly, but was settled within 4 min. This effect of humidity change on the leaf temperature control was larger under higher temperatures than under lower temperatures. As shown in figure (d), when the air movement was increased to 1 m/sec, effect of those disturbances was made smaller.

In order to analyze the response characteristics in the leaf temperature control in more detail, the step response from 20 to 30°C was examined. Figure 4 shows a step response in leaf temperature control under 60% RH and air movement of 0.3 m/sec in darkness. When the temperature rising, the delay time was 1.3 min, and the settling time was 5.3 min. The overshoot was 2.3°C, where the air temperature became 39.5 C at its maximum. The leaf temperature was settled under the air temperature of about 33°C. When the temperature falling, the delay and settling times were 2.9 min and 11.0 min, respectively, where the overshoot was 1.3 C. When the leaf temperature was settled to 20C, the air temperature became 21° C.

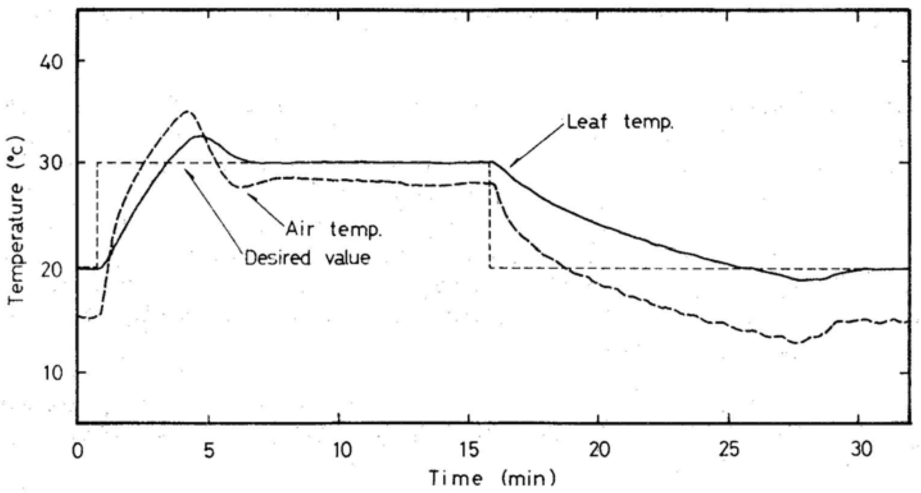


Fig.6. Step response in leaf temperature feedback control (RH=60%;air velocity =0,3m/sec irradiance 200μW/mm2)

Table 1. Characteristics in step response of leaf and air temperature feedback control

Air temperature feedback							
Environmental condition		settling time (min)		control area (°C·min)		delay time (min)	
		rising	falling	rising	falling	rising	falling
Darkness air velocity of 0.3 m/sec	RH : 80%	3.5	8.9	9.04	35.91	0.30	2.90
	RH : 60%	3.7	6.0	8.31	17.21	0.35	1.10
	RH : 40%	3.4	4.8	7.46	11.44	0.45	0.65
Darkness air velocity of 1.0 m/sec	RH : 60%	3.5	6.8	7.40	19.19	0.30	1.30

Leaf temperature feedback							
Environmental condition		settling time (min)		control area (°C·min)		delay time (min)	
		rising	falling	rising	falling	rising	falling
Darkness air velocity of 0.3 m/sec	RH : 80%	5.5	17.6	19.49	66.58	1.05	5.75
	RH : 60%	5.3	11.0	18.55	36.39	1.30	2.90
	RH : 40%	5.8	7.6	19.55	25.46	1.60	1.85
Darkness air velocity of 1.0 m/sec	RH : 60%	4.8	7.7	14.10	25.06	0.85	1.90
Irradiation air velocity of 0.3 m/sec	RH : 60%	5.5	13.6	19.17	42.46	1.35	3.15

Figure 5 shows a step response under an increased velocity of air movement, where the velocity of lateral air movement was 1.0 m/sec at 60% RH in darkness. In this case, the delay time, settling time and overshoot were made smaller than those under lower velocity of air movement of O. 3 m/sec.

Figure 6 shows a step response, where the leaf was irradiated by a tungsten lamp with an intensity of 20 mW/cm2 at 60% RH and air velocity of 0.3 m/sec. When the temperature rising,the delay and settling times were similar to those in darkness. When the leaf temperature was settled to 30°C ,the air temperature was 28.5°C. On the other hand,in the case of falling temperature,both delay and settling time were larger than those in darkness. This response indicates that the radiation to the leaf increases cooling load in the leaf temperature feedback control.

Thus, from the step responses, we could observed different characteristics under different environmental conditions. Table 1 shows the comparison of those characteristics between air and leaf temperature feedback controls under different environmental conditions.

In the case of rising temperature, the settling times in the leaf temperature feedback control were approximately 2 min longer than those in the air temperature feedback control. The control areas in the leaf temperature feedback control were almost 10 min per C larger than those in the air temperature feedback control. The delay times in the leaf temperature feedback control were approximately 1 min longer than those in the air temperature feedback control. In the case of falling temperature,the delay time in the air temperature feedback control was affected by the air humidity. With increased air humidity, the delay time was made longer. The effect of the air humidity on the delay time was magnified in the leaf temperature feedback control. The delay time at the air humidity of 80% RH was 3 times as large as that at 40% RH. In the settling time and the control area, this phenomenon was also observed clearly. Thus, the falling characteristics were greatly affected by air humidity. The delay time as well as the settling time and the control area in the leaf temperature feedback control was approximately 2 times as large as that in the air temperature feedback control in the case of falling temperature. In the leaf temperature feedback control, the time of the heat transfer between the air and the leaf was one important element of the delay in the control system. Accordingly, it is necessary to promote the heat transfer between the air and the leaf, to obtain more reliable characteristics in the leaf temperature control.

Thus, the response characteristics in the feedback system of the leaf temperature control were affected by the environmental factors, but, as shown in these experiments, the effect of those desturbancebwas rapidly eliminated by the compensation action in the feedback system. This system made it possible to control the leaf temperature with the setting the desired value.

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VIII. REACTIONS OF PLANTS TO LONG ABSENCE OF LIGHT

V. M. Leman and T. N. Chmanaeva

Artifical Climates Laboratory of the K. A. Timiryazev Academy of Agriculture,
Moscow U. S. S. R.

Having studied for many years the influence of artificial lighting on the growth and development of plants,we have (LEMAN 1976,1971) during the past years studied the reactions of plants in prolonged darkness greatly exceeding the normal photoperiodic succession of the photo and nyctiperiods, to which the plants became accustomed during evolution.

An abrupt and prolonged suspension (on the order of 10-15 days) of plant lighting can be observed on cultures in Phytotrons, greenhouses in very northern latitudes,underground and finally in cosmic conditions.

The dynamic of physiological processes in plants in the case of darkness , as well as their degree of resistance to the absence of PAR are still not very well known (JOST 1914, PRIANICHNIKOV 1945, TOLMATCHEV 1946 ,AGAEV 1970) .

But at the same time these problems present a great theoretical interest as far as being an aspect of the theory for plant resistance to unfavorable factors of the surrounding environment. Until the present time a study of extreme conditions to which plants are subjected has been limited generally to a study of high and low temperatures,water insufficiency or excess, high ground salinity, and air pollution.

At the artificial Climates Laboratory of the K. A. TimiryazevAcademy of Agriculture the reactions of plants to a prolonged absence of light has been studied for many years by a team of several researchers: T. N. CHMANAEVA, G. M. NONIKOVA, L. C. PARFENOVA,K. M. VINAROVA, O. P. VLASOVA.

Young tomato and cucumber plants grown in growth chambers with regulated climatic parameters were used as subjects. Air temperature during the light period, 23-25°, and during nightime,15-16° . Lighting period, 16 hours per 24 hours. Light sources: "Daylight" fluorescent lamps or xenon lamps "DKCTB 6000 " with water cooling. Lighting on the order of 100 W/m2 and less, depending upon need. Mineral nutrition- Knop solution at various concentrations. Relative air humidity 50-70% RH.

The results obtained on plant resistance to unfavorable conditions of the ambient environment showed that suppressing light provoked from the first day already a decrease of the amount of nucleic acid in the cell nuclei and a decrease in the volume concentration of ARN in the cytoplasm.

In the meristematic cells in the growth elongation zone of the tomato stem a decrease in the dimensions of the nuclei and an increase in the plasma-nuclei relation is found after two days of darkness but above all after four days. In prolonging darkness, a part of the nuclei become fragmented and are entirely destroyed.

Prolonged darkness (6-7 days) for tomato plants,which produced the destruction of nuclei, provokes a loss of cells in the growth elongation zone and stopping of the formation process, after which stopping of plant growth and development is observed.

Externally plant reaction to prolonged darkness is observed by the stopping of growth of the plant, loss of leaf turgidity, the appearance of necrosis spots on the leaves, browning and root deliquescence.

In the case of a regulated thermic state, the first symptoms of damage appear after four to five days of darkness: the total loss of turgidity and desiccation after 7-9 days.

In the case of darkness at root endings, a decrease of the zone of coloration by chromic-halucyanin alum, is observed, in other words, a large decrease in the amount of nucleic acids.

At the moment of leaf traumatism, the cells of the root endings become compressed tangentially and for the most part do not have nuclei. The remaining nuclei and nucleoles are smaller. An abnormal metabolism is observed with an excessive accumulation of ammoniacal and amine nitrogen, first taking place in the roots

The observed damage of the albumin and an ammoniac accumulation cannot be considered to be the main cause of the death of the plants,they are only links in the modification of the metabolism, which begin by an abnormal structure of the cytoplasm; it can be assumed that a decrease in the quantity of nucleic acids has a certain value.

A study of tomato and cucumber chloroplasts by means of an electronic microscope showed that already two days of darkness starts their destruction. It begins by a decrease in the number of granas,on their surfaces, a change in the compactness of the structures cf the components a decrease in the thickness of the tilacoid membranes and the distance between them.

These modifications increase with the time plants spend in darkness. After 5 days the appearance of prolamellae (from 1 to 9) is observed in the chloroplasts. After 6-10 days the destruction of the chloroplasts is more active. The prolamellar bodies become damaged, losing a pseudocristalline structure •en the chloroplasmic walls become damaged: the remaining individualized granas and tilacoids are again found directly in the cytoplasm.

The prolammelar bodies do not appear. This shows that the formation of prolammelar bodies is not only one of stages in the formation of chloroplasts but of its despruction.

Prolonged darkness produces as well a strong influence on the photosynthetic apparatus of plants.

The functional activity of the chloroplasts decreases (Hill reaction,photophosphorylation), and there we observed degradation in the rhythm of their movements in the cells of the palisade parenchyma.

In young cucumber plants and in prolonged darkness a decrease in the quantity of the pigments is observed at the same time as their partial resynthesis: chlorophyllA after 4 days of darkness and carotenoids the 6th day. At the same time the progressive *decrease* of the foliar absorption of physiologically active radiations (PAR in the 400-700 nm zone) is observed at the expense of an increase in the rate of reflection and transparence,but without an important shift of the maxima of the spectral curves.

During a study of the reactions of plants in darkness it was found that all plants do not possess the identical resistance to prolonged darkness. This is determined by the specific particularity of the plant as well as by cultural conditions.

In modifying cultural conditions it is possible to increase somewhat the resistance of plants and to increase their subsequent regeneration by lighting after darkness.

Above all it has been noted that excluding nitrogen from the Knop nutritive environment , on the basis of which the plants were cultivated, produces an important decrease in damage due to darkness. Plants in darkness, cultivated with nutritive solution without nitrogen but with a sufficient quantity of phosphorus produces a more rapid reestablishment of normal vitality. The same thing is observed in plants in darkness with ordinary water,they do not lose their turgidity until after 15 days of darkness and external damage is very slight.

Another factor which determines plants resistance is air temperature. A lowering of the temperature (within certain limits) retards the process of damage (MISRAKH, LISOVSKY, TERSKOV 1973). As are shown by the research carried out in our laboratory by K. M. VINAROVA, lighting conditions before setting in darkness have a very great influence on plants resistance. A strong lighting intensity (about 100 W/m2 PAR) makes it possible to grow hardy plants but which, however,suffer heavily in darkness. Inversely, after relatively weak lighting (10-20 W/m2 PAR) plants adapt themselves more easily to darkness: the loss of organic matter is less, pigment formation is more active, and damage to the chloroplast structure is less.

The results obtained in the growth chambers in placing plants in darkness can be used in the case of a study of plants cultivated in the winter in greenhouses with low light intensity.

The above makes it possible for *us* to conclude that,on the one hand, a strong resistance for a series of plants, to the absence of PAR,and on the other hand, the possibility for increasing its resistance by the use of specific culture methods ,in other words, an orientation of plant resistance to stress,produced by an abrupt change in the normal conditions of the ambient environment.

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IX. SIMULATION OF THE PLANT STAND PRODUCTION PROCESS

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A mathematical model for the simulation of plant transpiration, photosynthesis and productivity is presented by Z. BICHELE,H. MOLDAU and J. ROSS. In this model photosynthesis and transpiration are coupled through stomatal resistance which *is* a function of the water potential and of photosynthetically active radiation (PAR).

Leaf temperature, leaf water potential,stomatal resistance and transpiration are calculated by solving the system of equations regarded as the submodel "soil-plant-atmosphereand which determines the above-mentioned processes as functions of soil parameters,meteorological conditions and plant biophysical parameters. Gross photosynthesis is presented by the generalized rectangular hyperbola, respiration- by the concept of McCree, Net photosynthesis determined as a difference between gross photosynthesis and plant total respiration. The specific feature of the model is that the leaf temperature,the leaf water potential and stomatal resistance are calculated step by step for every time moment in accordance with the soil water content and with meteorological conditions such as radiation,air temperature, air humidity and windspeed. The model consists of about forty various parameters and allows one to perform various numerical experiments for the simulation of the diurnal course of photosynthesis and transpiration at various soil water content, for the simulation of these processes over a long period (about 2 to 3 weeks) without rainfall when the soil water deficit increases. By this model it is also possible to study the influence of the meteorological and plant parameters on the transpiration and the photosynthesis of plants with powerful and weakly developed root systems for two classes of soil.

Some results of the numerical experiments will be shown.

On Fig.1 relative photosynthesis F and relative transpiration E are shown as functions of the soil water content for two textural classes of soil: sandy loam "Pachappa" and clay loam "Chino".

When a deficit in the plant water supply has arisen, the low values of it do not markedly influence transpiration and photosynthesis but a further increase of water deficit causes a rapid decrease df the transpiration and photosynthesis. This decrease is especially steep for the sandy loam "Pachappa" and in comparison to the photosynthesis is the transpiration more sensitive to the plant water deficit.

On Fig.2 gross photosynthesis light curves are shown at different values of the soil water potential psi-delta . The solid lines represent to the clay loam "Chino", the dashed ones-the sandy loam "Pachappa". The upper curve at the psi-delta =-0.1 corresponds to the optimum water supply, the middle one-to the moderate water deficit when stomata are partly closed and the lower one at psi-delta = -8-to strong water deficit with almost closed stomata. The comparison of the two light curves at the psi-delta = -2.5 indi cates that plants growing in the clay loam suffer less from the soil water deficit. The difference between the upper and the lower curves shows how much the productivity may decrease when it *is* limited by the water supply. Under favourable water supply conditions a rise in the incoming solar radiation increases productivity but at a water deficit the picture is more complicated. At low radiation values the increase of the incident radiation rises photosynthesis only up to an optimum radiation value. Above this value further increases of radiation causes a decreases of photosynthesis and by increasing the water deficit the optimum value of radiation decreases.

The diurnal course of photosynthesis and transpiration on various days during a period without rainfall is presented on Fig.3 . In the first day the water supply is still at its optimum. On further days the continuous decrease of the amount of soil water causes disturbances in the plant water supply at noon,as a result of which stomata close partially and photosynthesis decreases. On the 15th day the plant water supply is disturbed to such a degree, that net photosynthesis becomes negative at noon. The diurnal course of transpiration shows no minimum at noon.

On Fig.4 is shown the time course of various productivity parameters during a 19-day period without rainfall. The daily course of meteorological parameters corresponds to a typical Estonian cloudless June days. Lower curves show a change in the water potential. The upper curve corresponds to the soil water potential, the central one-to the root water potential and the lower one-to the leaf water potential. The difference between the two upper curves characterizes the resistance to the water flow in the soil, the difference between two lower ones being resistance to the water flow inside the plant. The upper columns give daily totals of gross photosynthesis,respiration and transpiration. The difference between gross photosynthesis and respiration yields net photosynthesis. It must be noted that plants growing on the clay loam "Chino" are able to produce without an additional water supply to the maximum extent of two and a half weeks.

The slides demonstrated here show that the mathematical model elaborated by three authors simulates well the processes of transpiration and photosynthesis when there arises a water deficit and by means of this model we can better understand in which wat meteorological, soil and plant parameters affect physiological processes which determine plant productivity.

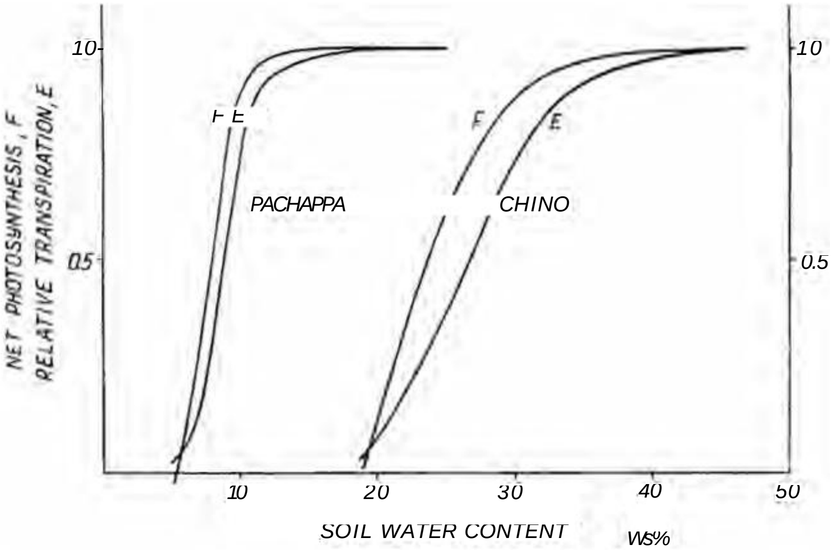

Figure 1

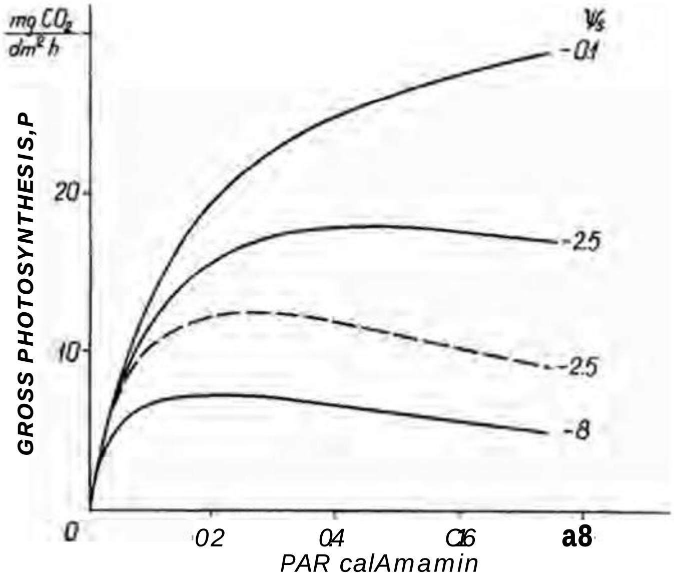

Figure 2

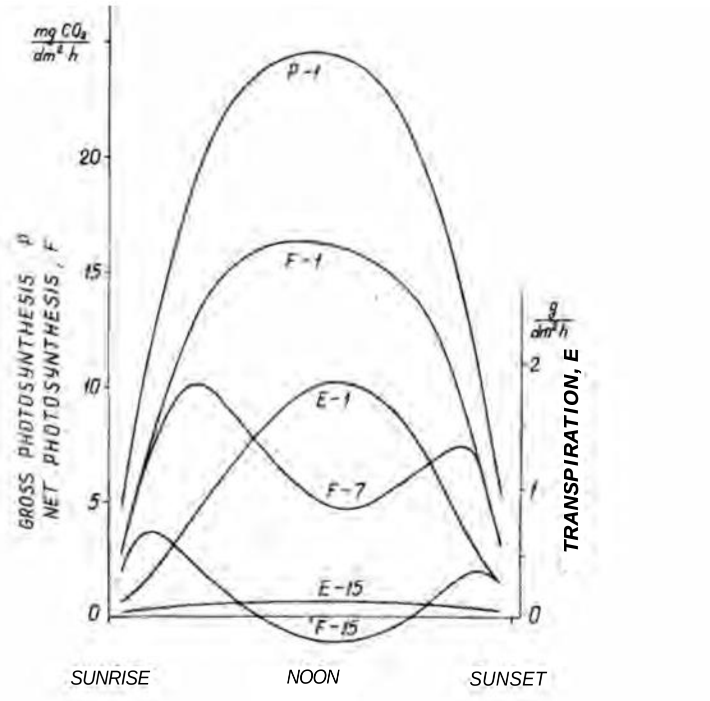

Figure 3

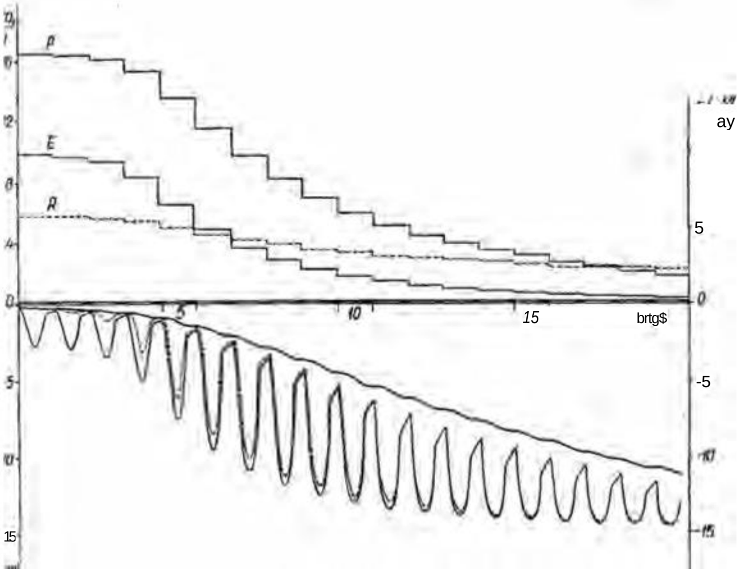

Figure 4

X. EQUIPMENT FOR MEASURING LIGHT INSIDE THE CANOPY IN PHOTOSYNTHESIS STUDIES

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N. B. Authors indicate that a more detailled paper on the same subject has been published in Silva Fennica (vol.10,1976 n°2, 94-102).

Abstract. Light intensity inside the canopy varies considerably both in space and time. To avoid this difficulty, we have developed an apparatus which is disturbed as little as possible by the above-mentioned variation. The construction is based on the linear relationship between light intensity (measured using silicon diodes) and photosynthesis. This procedure permits linear operations (summing and integration) to be carried out on the output of the diodes without any loss of accuracy. There are five diodes in each assimilation chamber. Let V.(t) denote the output of the j:th diode at the moment t, t ı the beginning instant of the i:th photosynthesis measurement, and t,ı the moment when the i:th measurement is completed. Our equipment is constructea so that summing and integration takes place according to the following formula :

$$\int_{t_{1i}}^{t_{2i}} \sum_{j=1}^{5} V_j(t)\,dt.$$

A model, in which the independent variables include light,measured with the present equipment,and temperature,fits the photosynthetic rates well even inside the canopy.

Introduction. Photosynthesis has been studied quite intensively during the last few decades. However, it is rather surprising that most of the studies have been performed in the laboratory and the monitoring of photosynthesis under field conditions is the exception rather than the rule. To my way of thinking this is a very unusual situation, since only in the field can we evaluate the importance of different aspects of photosynthesis. The monitoring of photosynthesis under field conditions is not very difficult from the technical point of view, so the reasons for prefering laboratory studies are presumably to be found elsewhere.

The first crucial point is the light measurement especially inside the canopy, where there is a pronounced temporal and spatial variation in the light intensity.

The second important point is the statistical analysis of the field data, since the independent variables light and temperature are strongly intercorrelated. These difficulties are not so great that fielAstudies would be fruitless.

In the following paper, I will describe a system for measuring light in photosynthetic studies carried out in the field, and then I will give some examples of the statistical analysis of the data obtained.

The Equipment

General Setup of the Field Station

The light measuring equipment forms part of an automatic system for measuring gas exchange,growth and environmental factors in the field. Net photosynthesis and transpiration within the canopy and ground vegetation are monitored continuously during the growing season in a young stand of Scots pine (*Pinus silvestris* L.) with a few scattered Norway spruce at the University of Helsinkis'Forestry Field Station in Central Finland. The system includes two infrared gas analyzers (URAS,Hartmann & Brown AG,BRD) and 20 trap-type pneumatically operated assimilation chambers or cuvettes. One analyzer is used for monitoring CO2 levels and the other for H20 levels. The cuvettes are closed in a pre-arranged sequence for 100 seconds. The CO_2 concentration of the air in the cuvette is measured before the cuvette opens. Photosynthetic rate is determined on the basis of the difference between the CO_2 concentration inside and outside the cuvettes. A data-logging unit,supplied by Nokia Oy, Finland, is used to control the system and to collect the data for photosynthetic rate,transpiration rate,temperature and light.

Requirements for a System to Measure Light Intensity

The output voltage of a phot-voltaic cell (Siemens BPY H) is almost a linear function of the light intensity at low illumination in an electrical circuit as shown in Fig.1 (cf. Optoelectronics semiconvactors 1974). When the light intensity increases the output reaches a saturation level and the cell generates a constant voltage. The threshold valve of the saturation level is greatly dependent on the value of resistance R. The relationship between the light intensity and the output of the photocell is rather similar to the relationship between photosynthesis and the light intensity at constant temperature. Thus it is possible to construct a linear relationship between the photosynthetic rate and the output of the photocell by including a suitable resistance in the circuit, which furthermore,makes it possible to construct a piece of equipment for measuring light intensity in photosynthetic studies. This aparatus is not disturbed by the great spatial and temporal variations in light intensity inside the canopy.

The equipment has been designed on the basis of the following mathematical analysis of photosynthesis . Let P (t) denote the total amount of CO_2 fixed in photosynthesis at the moment t during the growing season. The photosynthetic rate f is defined as the time derivative of P (t), thus

$$(1)\quad F = dP/dt$$

It there is sufficient water available in the soil for the plant, then the photosynthetic rate is determined primarily by the temperature x and by the light intensity y (cf. HARI and tJJUKKANEN 1974) thus

$$(2)\qquad f = f\ (x,y)$$

The photosynthetic rate is most frequently measured in the field by the so-called open measurement system. A living branch is placed in a chamber. The cuvette is closed for between 60 and 120 seconds before the CO concentration in the cuvette is measured. It is then compared with the CO2 concentration of the air outside. The cuvette is opened after the measurements have been made. Let t_{1i} be the moment at which the cuvette is closed for the i:th measurement and t_{2i} the moment when the cuvette is opened. When Eq.(2) is integrated from t_{1i} to t_{2i}, Eq.(3) is arrived at

$$(3)\qquad \int_{t_{1i}}^{t_{2i}} \frac{dP}{dt}\,dt = \int_{t_{1i}}^{t_{2i}} f(x(t), y(t))\,dt.$$

The left hand side of Eq.(3) represents the amount of CO_2 fixed in photosynthesis during the time when the cuvette was closed at the i:th measurement obtained directly with IRGA measurement. The right hand side of Eq.(3) can be simplified by supposing that the effect of temperature and light intensity on photosynthesis is multiplicative, i.e.

$$(4)\qquad f(x,y) = f_1(x)\ f_2(y)\ ,$$

where f_1 is the effect of temperature and f_2 the effect of light intensity. Let us further suppose that temperature is constant during the period when the cuvette is closed. The left hand side of Eq.(3) can now be evaluated as follows

$$(5)\qquad \int_{t_{1i}}^{t_{2i}} f(x(t),y(t))\ dt = \int_{t_{1i}}^{t_{2i}} f_1\ (x(t))\ f_2\ (y(t))\ dt$$

$$= f_1(x(t_{1i}) \int_{t_{1i}}^{t_{2i}} f_2\ (y(t))\ dt$$

There are great spatial fluctuations in light intensity in the cuvette caused by shading of the branches. The disturbing effect of shade can be to a great extent reduced by using several cells in the cuvette.

The requirements put on the light measuring equipment discussed above can be summarised as follows:

1. There are n cells in a cuvette.

2. Let V_{1j} denote the output voltage of the cell j. The relationship between output V_{1j} and photosynthetic rate must be linear at constant temperature, i.e.

$$f(x,y) = a\, f_1(x)\, (V_{1j}(y) + b), \text{ when } j = 1,2,\dots,n. \tag{6}$$

3. The apparatus has to be able to compute the following integral (cf.KUBIN 1971)

$$V_{3i} = \int_{t_{1i}}^{t_{2i}} \sum_{j=1}^{n} V_{1j}\,(y(t))\, dt. \tag{7}$$

Results. A system was designed and built which fulfills the above requirements.The value of resistance R_L (cf. Fig.1) was calibrated so that there is a linear relationship between the output voltage of the photocell and the photosynthetic rate at constant temperature.This was performed empirically and the value 3 kΩ was obtained. In Fig.2 the IRGA measurements are shown as a function of the output of ELP in the temperature range 10°-15° C during the period 1974-06-06- - 06-23. It is clearly evident that the linear relationship between the IRGA measurements and the Output of the ELP holds rather well.

The maximum output varies from one summing amplifier to another as a result of small differences in calibration.For this reason,the output of each amplifier is normalized so that it has the value 100 in full sunlight during summertime.

Let P_{ki} denote the result of the i:th IRGA measurement of the k:th cuvette. When Eqs. (3), (6) and (7) are combined the final model is obtained

$$P_{ki} = a\, f_i\, (x(t_{1i}))\, (V_{3ki} - b\,). \tag{8}$$

where f_1 is the effect of temperature, V_{3ki} is the output of the ELP, and a and b are parameters which have to be estimated. The function f and parameters a and b were determined separately for pine and spruce. The estimation was based on data collected during the period 1974-06-25- - 07-03 for Scots pine and during the period 1974-07-31- -08-04 for Norway spruce. The functions f_i which were obtained are shown in Fig.3. The measured photosynthetic rates and those computed from the model (Eq. (8)) for pine during the period are depicted in Fig.4 and for Norway spruce during the corresponding period in Fig.5. The model explained 86% of the variance in photosynthetic rate for Scots pine and 89% for Norway spruce during the periods shown in Figs.

Discussion. The temporal and spatial fluctuations in light intensity are very pronounced, especially inside the canopy The moving shadows of branches bent by the wind cause sudden changes in the light intensity (cf. LOGAN and PETERSON 1964, HARI and LUUKKANEN 1974). The aim of the present study was to develop a system for measuring light intensity in photosynthetic studies. This apparatus is not likely to be disturbed by such fluctuations in light intensity. The design of the equipment was based on a mathematical analysis of the measurement technique for photosynthetic rate in a so-called open measurement system.

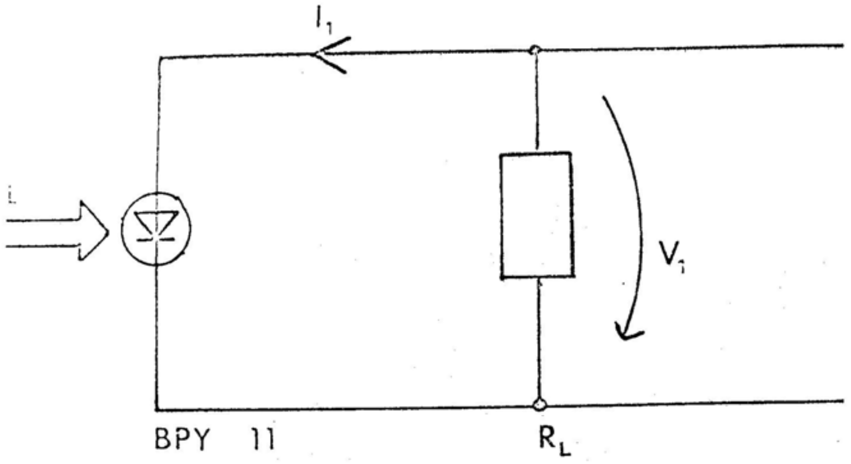

Fig.1.The test circuit for the photo-voltaic cell BPY 11

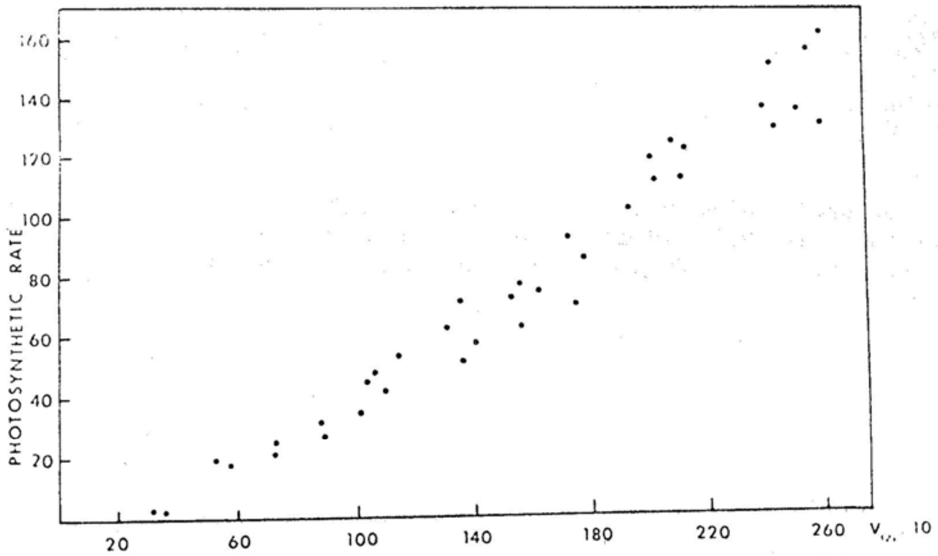

Fig.2. The correlation between photosynthesis rate and the output of ELP in the temperature range 10°C-15°C during the period 1974, 06-06 to 06-23.

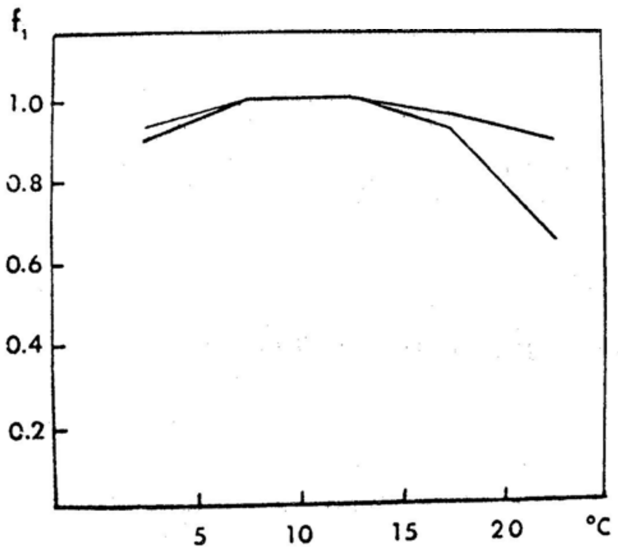

Fig.3. The function f_1, for scotch pine (thin line)and for Norway spruce (thick line)

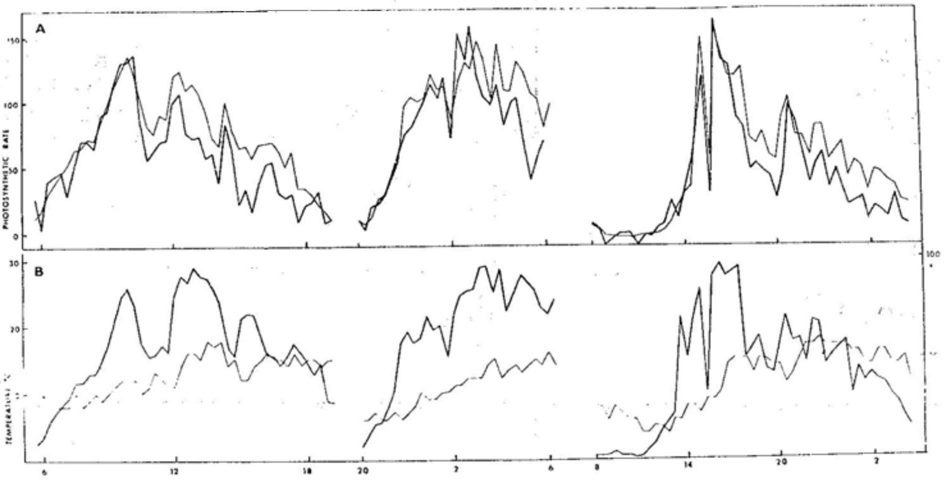

Fig.4 A. Measured (thick line)and according Eq.(13) computed photosynthetic rates for the days 1974 : 06-06, 06-07 and 06-10 for Scotch pine
B. The output of ELP (thick line) and temperature (thin line) for the above days

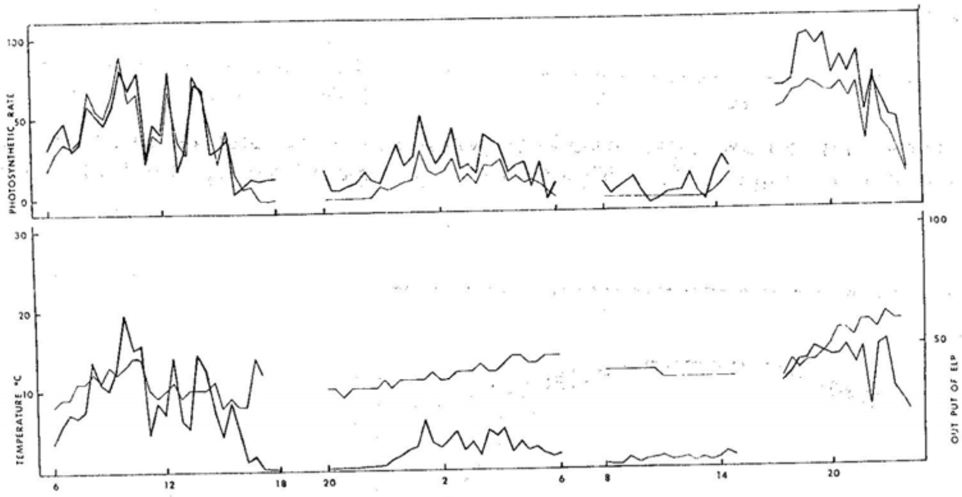

Fig.5. As Fig.4 but Norway spruce during the period 1974: 07-21 to 07-25

Since the ELP has to operate under field conditions,special care must be taken in the designing and implementation of the circuits. The components must operate reliably over the large temperature range (-10°C- 40°C) and moist field conditions. The ELP proved, however, to work well under extreme field conditions even those of early winter.

The design of the ELP is essentially based on the properties of the photocell(BPY 11) . There seems to be some similarities between the characteristics of the photosynthetic rate and those of BPY ll,since otherwise such high correlations could not be obtained. The photocell (BPY 11) can be replaced by a linear photosensor but then much more complicated electronics or an on-line computer must be employed.

The piece of equipment was built to fulfill the requirements presented in Eqs. (6) and (7). The degree of accuracy of the measurements was satisfactory although it can be improved further. At the moment, measurement of the photosynthetic rate represents the weakest point in the system. Even this can be considerably improved by further developing the system. Attention must be paid to variations in the flow rate of air through the IRGA and to the degree of accuracy of the IRGA measurements.

Statistical analysis carried out on the data obtained showed, however,that the results were better than had been expected. The model (Eq.(8)) explained over 80% of the variance in the photosynthetic rate in any of the computed periods in summer 1974. The measured and computed photosynthetic rates presented in Figs.4 and 5 are merely examples to illustrate the fitness. In addition it must be kept in mind that the measured and computed photosynthetic rates are independant of each other, since the parameters in the model are estimated from data collected during the period 1974-06-25- -07-03 for Scots pine and 1974-07-31- -08-04 for Norway spruce.

Measurements of photosynthetic rate have been analysed rather superficially in the literature. There are only a few papers available, in which some statistical analysis has been performed (cf. REIFSNYDER W. E.1962). In particular,papers which consider photosynthesis inside the canopy are rare. This is most propably due to the great difficulties involved in measuring light intensity inside the canopy. Statistical analysis of photosynthetic data is also rather complicated since the independent variables,temperature and light intensity,are strongly intercorrelated and also because water deficit and temperature have a pronounced interaction in photosynthesis (HARI and LDUKKAAEN 1973). Thus it is difficult to use standard statistical methods in the analysis.

The use of ELP and careful statistical analysis of the data make it possible to study photosynthesis in field conditions to an extent which has earlier only been possible in the laboratory. In this way, attention can be focused in the study on the ecologically important aspects of photosynthesis in the field.

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XI. THE POTENTIAL PRODUCTIVITY OF PLANTS AND METHODS FOR REVEALING IT

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Together with:forecasts for the population increase of our planet,wich will reach 6 million people in the year 2000,more and more fiequently are heard appeals and misgivings,,ever more alarming, concerning an approaching famine accompanied by ineVi* table mortalities,and what is particularly unpleasant,is the fact that no measure has been taken nor anticipated at the present time to try to combat this prediction.

In addition, of late the battle against a lack of food products has become complicated by the indispensible need to protect nature against pollution and the possible destruction of the biosphere.

The massive use for culture of forest surfaces and other natural landscapes, which were until recently considered as an important reserve for agriculture, is currently, with reason, being considered as inadmissible. The fact of considering hydraulic bassins, including oceans, as food sources both animal and plant, for man is a very complex problem, still insufficiently known, but which must be resolved with urgency and with indispensible gravity.

The synthesis of food products from mineral elements on an industrial level for replacing natural food is still a far way off in terms of its practical application. What must be done? How can the future problem and, even partially,the current problem of normal world nutrition be resolved? If it is true that the best cereal yields currently,especially that of wheat,have attained or almost so their maximal limits,it is difficult not to be pessimistic about the fate of future generations. It therefore becomes absolutely necessary to increase world plant productivity and to raise agricultural output.

For this, it must above all be proposed that the present output is still a way off from maximal limits and,in certain conditions,they can still be increased. With this aim in mind, without being satisfied with current ideas about plant productivity, there is good reason to elucidate potential possibilities of the increased production of useful plants in a farily short time,as well as conditions in which this can be attained. It is this fundamental problem, essential for all the natural sciences,of proposing particular biological and economic plant potentials which is being studied in our laboratory for many years in entirely artificial conditions.

In the mid 20th century the possibility of replacing sunlight for plant culture by electric light was forseen and this remarkable achievement should not be underestimated. This achievement put a new powerful ecologic factor into the hands of researchers, allowing them to replace natural sunlight which is variable and outside of their control. From this time on, and added to other known factors,already mastered for a long time-mineral and carbonated nutrition,hydric state and thermic conditions, came a basic cosmic factor-adjustable luminous energy from electric radiation sources. It is only afterward that it was possible to study plant behavior in entirely artificial conditions, able to be controlled and realized in growth chambers or in specialized places that are often referred to as phytotrons.

In our laboratory, well before others,luminous sources of very strong intensity,nearly equivalent to solar radiations at midday , were used for plant culture, thanks to lighting equipment,made up of 16 incandescent lamps with an incorporated reflector of 300 or 500 watts,laid out on 1 m2 at a distance 20-30 cm above the top of the plants.

In order to avoid too strong heating at the expense of infrared radiations, a water filter (running water, 25 mm thick on the glass ceiling of the irradiation equipment) is used which absorbs radiations from 1100 nm. Specific electric power installed per square meter reaches ur to 5-8 Kw. Thus,an energetic flux reaching **600 - 900** w/m2 can be obtained.

It is only thanks to the use of such intense lighting that completely new indications about potential productivity of plants were revealed and to greatly reduce the length of their reproductive development. But,much more important are the results of our research which led us to the conclusion that plants can be much more productive than imagined

What do we known of the potential productivity of plants? Above all,it should be underlined that paradoxically in the literature is found no concordant and precise information concerning productivity in general, and even more so for the individual productivity of plants.

Generally, under the term "plant productivity" is included either photosynthesis by unit of time,acting of foliar surface, or the plant volume for which the plant had been cultivated. Lt seems that these two indixes must find themselves in direct correlation, but as experience shows, sometimes they are in an inverse relation. Thus,a high coefficient of photosynthesis can correspond to an important plant volume and a relatively average fruit or seed yield and inversely ,with a an identical coefficient of photosynthesis or even lower,a much higher yield of fruits of seeds than in the first case can be obtained during a much shorter period.

Thus,for example,in our experiments,tomatoes,for a photosynthesis that was not higher than the average and in 60-65 culture days calculated from sowing to harvest, gave fruit yields reaching 24 Kg/m2,keeping in mind that the weight of the fruit represents 80% of the fresh volume of the plant, in other words,for the root weight stems and leaves,only 20% remains. Therefore,the usable part of the harvest corresponds to 80% of the biologic total mass,while normally in plants there is an inverse relationship between plant and reproductive organs.

Taking into account the experimental results,which characterize the productivity of photosynthesis,certain specialists conclude that the yields of winter wheat nearing its limit reach about 100 quintals /hectare. Effectively,several research center in the USSR and abroad arrive at similar values for field culture. But the same yields do not characterize the real productivity of the plants,that is to say,not their individual productivity,but the final harvest of field cenose is complex in its entirety , where the productivity of each individual plant is brought back to a minimum. In this case, a higher quantity of seed is used for sowing and the reproductibility coefficient frequently does not reach 25. Thus, according to established norms by the Secretary of Agriculture of the USA,an average farmer obtains for each grain of wheat sown a quantity equal to 21 seeds in a new harvest. It is evident that in this case the final *yield* of the plants is not determined by its potential productivity, which is much higher,but by unfavorable conditions of life created by very dense sowing.

Consequently,an economic appreciation of the productivity of plants in terms of the final yield in seeds on a defined surface refers to the observed characteristic of the sowing and agrotechnical methods and in no way defines the real individual productivity of the plants,which can be different and very high. Thus,for example, in a sample of Aurora winter wheat,of the VIR Institute,in our artificial lighting installation under a permanent high temperature (27-30°C) and in continuous lighting, we were able to count the plants which gave up to 100 productive stems and seed yields at the rate of 4,000-5,000 for a plant in 150 days of growth.

In the same sample we found a more precocious type of plant which began its earing 30 days after sowing and its maturity in 70 days. We harvested 2200 seeds weighing 103 g. With the same plants,up to 36 heads can be had on the same area and, since at the time of earing there are up to 45 stems,more than 3 kg of seeds can be harvested,in other words 3 times more than for a harvest of 100 quintals/hectare with an expenditure of seeds for sowing from 15-16 times less.

Is it not timely to attack the problem of obtaining very high yields, up to 300-400 quntals per hectare, perhaps even more,for relatively early wheat but in any case not for winter wheat,with a decrease of 15 times the seeds necessary per hectare? To obtain such harvests great individual plant productivity is above all necessary and the problem ,probably very complex, can be summed up as obtaining varieties of wheat where each plant in less dense sowing is capable of producing more than 2000 seeds for each seed sown.

If this is be the case for some individual plants,it is essential that the impossible be accomplished so that this phenomenon becomes generalized . It is precisely around this phenomenon that the essential work of physiologists,geneticians and breeders,who dispose of artificial climate laboratories and phytotrons,be oriented.

If,up to now,it is estimated that the growth period for spring wheat is from 80-120 days and winter wheat between 240 and 360,there is a need presently,as a result of our work on culture in entirely artificial conditions to reduce these periods to 45-70 for the former and for 120-170 for the latter. This means,that under certain conditions,close to the optimal state,the growth period for wheat may be reduced. It would, then,be earlier. In addition, in these conditions,in spite of the reduction of the growth period length,the productivity of the wheat plants does not decrease but,on the contrary, increases.

In these artificial conditions and in one year we have been able to obtain three successive generations for the "Aurora" winter variety and for the early spring variety until 6-7 yields. This means that in artificial conditions ,the process of creating new selections can be activated from 3-7 times,depending on the variety. One can increase in the same proportion the creativity of the breeder *in* direction of productivity and durability.

Another important advantage of culture in artificial conditions for selection lies in the possibility that plants possess in certain culture conditions ,and under certain states,ways of showing not only a variability much stronger in relation to the mean,but also of bringing out very productive individuals. Thus, in our tests in constant artificial conditions,in the posterity of one plant found in the Aurore variety and multiplied until the 7th descent,important variations in autopollinisation are observed within the limit of a single ear. Of 36 seeds sown in absolutely identical lighting conditions,it *is* observed,each time during 7 generations,that early plants need 70 days for maturity and late plants only give crops after 160 days,in other words,plants that differ greatly as to their individual productivity .

Thus,artificial conditions of plant culture are methods for studying individual particularities for selecting and rapidly multiplying the most productive forms. The possibility of selection in artificial conditions for creating new varieties for natural conditions have been proposed by means of special tests on 6 descendants of Pirka barley and 3 of Aurora wheat obtained by means of artificial lighting installations. The observations for the development of all the plants,sown and observed in culture tests at the same time as the original material, as well as the enumeration of final yield has shown that the genetic code in artificial conditions is not modified in respect to the starting plant.

All that has been cited above leads us to the conclusion that there is good reason to re-examine our ideas on plant biology,as well as in the methods for culture in the field and in artificial conditions, whicl• will certainly give rise to a great increase in yields with more stability and certitude. Particularly, there is a need to re-examine and to specify ideas on the biological differences between the so-called winter and spring forms. Indeed,for a long time it has been known that in many southern countries where wheat has been cultivated for a long period,there is no distinction between the winter and spring variety,but they are distinguished only on the basis of early and late. This is probably the only objective division of these varieties.

In the case of plant culture entirely under artificial lighting, it is very important to know the minimal quantity of electric energy indispensible to obtain high yields. For that, it is necessary to determine:the length of the daily lighting period,its intensity and, of course, all the methods whick make it possible to reduce the length of growth in lighting installations.

Vernalisation is a process which greatly decreases the length of time plants must stay in Lighting conditions. Thus, it is normal to determine its importance in the case of wheat culture under artificial lighting of heavy intensity,particularly in the case of permanent lighting. The tests done to determine to role of vernalisation were begun by soaking seeds on filter paper in petri dishes at room temperature during 24 hours. Then,a part of the seeds were sown at the rate of 1 seed per 3 liter vase,and the others were placed in a vernalisation room in a permanent temperature of 1-2°C.

The plants in the vases were placed under lighting installations: 1- in permanent lighting 2- in 16h of daylight and 3- in 8 hours of daylight. The temperature was 27 – 30 C for all the subjects. It is precisely this air temperature that we believe is the optimum for rapid plant development.

30 and 50 days after the start of the test one part of the seeds that germinated in the vernalisation room were replanted in vases and placed in permanent lighting at a high temperature (27-30°C) . At the same time in the same conditions a sample sowing of seeds was realized ,having been humidified the night before. For the same time lengths that is to say 30-50 days, one part of the plants were transported from continuous lighting to 8 hours of daylight and inversely from 8 hours of daylight to permanent lighting. Thus,50 days after the start of the test we have 9 subjects which are presented in the table.

The first plants which eared 82 days after sowing were the Aurora plants, which had been kept at a high temperature all the time and in 16 hours of lighting. After 90 days the plants in a high temperature and permanent lighting began to ear. The wheat in 8 hours of daylight stayed at its vegetative state until the end of the test.

The earing of vernalized plants, in 30 and 50 days,began 120 to 130 days after the start of vernalization,at the *same time* as the control plants. Consequently in our test,vernalization did not activate the development of Aurora winter wheat, but on the contrary,retarded it precisely for the vernalization period.

Curious results were obtained with the plants of winter wheat of different ages that were permitted between 8 hours of daylight and permanent lighting. The plants that after 30 and 50 days of 8 hours of lighting were placed in permanent lighting, eared in 92-95 days and the plants that after the same length of time were displaced from permanent lighting into 8 hours of daylight remained at the vegetative state until the end of the test.

A comparison of these results proves the existence in wheat plants of the Aurora variety of a well known phenomena,the actinorythmic phenomenon of plants:the influence of age on the process of actinorythmic reactions which accelerate reproductive development. At any rate, the Aurora wheat plants,throueout their 50 first days of life, do not react by accelerating their ontogenesis to conditions of the actinorythmic state of culture. Is it not precisely in this phenomenon that lies the cause for the "win- ≥ terability" of the wheat,that is to say, their non earing in the case of spring sowing . In this case nearly two months are used for a period of termination of maturity for the reproduction of these plants. During the course of this period,lighting and temperature conditions are profoundly modified which provokes a braking in their growth and development.

Light is not only the energy source indispensible for the creation and accumulation of the biological mass ,it is at the same time a regulator of growth and development. Diurnal successions of light and darkness,which in temperate regions vary with the seasons, determine many processes of plant activity : modifications in the differentiating of plant cells,they are the factors which favor the passage of the molecular apparatus from the state of rest to an active state and,above all the

Table

Influence of Temperature (High and Low, for vernalization) and duration of Daylight on the Earing and the Maturity of the Aurora Variety of Winter Wheat.

N° subject	Culture conditions	Number of days for :		Total length of test
		earing	start of maturity	
1.	Permanent high T° (27-30°C) and permanent lighting	90	120	-
2.	Permanent high T° (27-30°C) and 16 hours of day	82	120	-
3.	Permanent high T° (27-30°C) and 8 hours of day	none	none	125
4.	30 vernalization days (+1 to 2°C), then permanent lighting at 27-30°C T°	120	none	125
5.	Vernalization control for 30 days since the start of test. Permanent high T° (27-30°C) and permanent lighting	90	none	95
6.	50 days of vernalization (+1 to 2°C) then permanent lighting at 27-30°C T°	none	none	125
7.	Vernalization control. Sowing after 50 days from the start of test. Permanent high T° and permanent lighting.	none	-	75
8.	50 days of 8 hours of lighting, then permanent lighting. Permanent high T°	92	125	-
9.	50 days of permanent lighting, then 8 hours days. Permanent high T°	none	125	-

orientation of the ontogenesis of growth towards reproduction.

Much actinorythmic research has shown that during periods of darkness very important physiological processes are unfolding, which not only control ontogenesis and morphogenesis but through them the global characteristics of useful plant production.

For any kind of actinorhythmic state, beginning with permanent lighting,including light,there is above all a need to define the action on the plant of its main characteristics: spectral composition and quantity of global energy and in the various parts of the spectrum. The total intensity of luminous radiation must be balanced with the air temperature surrounding the plant, in such a way that the leaves temperature be situated between 26 and 30°C.

When actinorhythms are used with lengths of variable darkness,particularly long periods,care should be taken that the nocturnal T° of the air be maintained at the level of daytime. A lowering of nocturnal air temperature always provokes a delay in reproductive development and lowers the accumulation of dry plant mass. Of course, all mineral elements and gaseous exchanges, as well as water,must be maintained at a favorable level for a rapid development and high plant productivity. This can be determined by special experiments.

Let us be reminded that many varieties exist where the possibility for generative multiplication is determined by the actinorythmic conditions of their culture. According to this precise character,they divide into nyctophile and nyctophobe plants, whose reactions to critical actynorythmic states of culture are inverse. For example, a nyctophobe species-the leafy cabbage of Japan-flowers in long day (up to 16 hours) and stays in a vegetative state for light lengths of 15 hours and under. A nyctophile species-oily Perilla-inversely only flowers in places where the leafy cabbages does not flower,in short day up to 15 hours and stays in a vegetative state above 16 hours of light.

Naturally in artificial lighting conditions nyctophile species culture is always more profitable than nyctophobe species. In the development of nyctophile and nyctophobe plants,darkness in determined cycles of 24 hours, presents an inverse influence for the same process: activation in the former and braking in the latter. But it should not be concluded that darkness in both cases defines or releases the same mechanism of development. For an active perception of darkness,nyctophile species need high air temperature. For nyctophobe plants,on the other hand, the remaining positive temperature may vary within large limits.

There is not useful thermoperiodism for plant ontogenesis. Even for the accumulation of dry tomato material, for which Went established thermoperiodic growth values, as everyone knows, a decrease of the temperature during darkness provokes+ a decrease of dry matter, and that even greater if the night is long.

In our actinorythmic research carried out entirely under artificial lighting, it has been shown that close infrared radiations, up to 1000 nm, inhibit the process of darkness in nyctophile species, and due to this fact, this action on the plant should be connected to photobiologic phenomena.

It is interesting to note that presently more and more results show that the flowering of the nyctophobe species is stimulated and that of the nyctophile species is retarded, when in the energetic flux there is a large quantity of close infrared radiations.

In summary, as a result of our numerous physiologic research carried out entirely in controlled culture conditions, we have found conditions for the culture of a certain number of agricultural species that give indexes for particularly high production. Certain results have already been noted above. The results obtained on tomatoes should be added and on a new hybrid species of radish created in our laboratory. This latter was obtained in record time following the interspecific crossing (radish x cabbage) which differs from the normal radish by slightly thicker and glabrous leaves ressembling somewhat the plantlet leaves of cabbage. The first two plants of this kind appeared during the 3rd generation in a group of diploid plants of the pure radish type. They were multiplied during one year by autopollination under a lighting installation and gave,during this period, 6 generations. Thus,since the beginning of selection until the creation of a new kind, only one year passed. This new kind of radish , which has edible leaves and tubors is of great use having practically no waste (at the most 3-5%) . The entire crop of this kind is usable and it is produced in intense permanent lighting for only 17 days, which makes it possible to harvest per year on the same surface of 21 crops with a plant mass close to 150 kg/m2.

The problem of the rapid increase of the usable part of the yield in the general biological mass of plants is one of the essential problems of horticulture. It was resolved with our tomatoes, as we noted earlier, where the fruit yield corresponds to about 80% of the general fresh weight of the plant. A similar report between fruit and plant mass has not yet been produced to our knowledge.

Six tomato crops per year on 1 m2 produce about 140 kg. of fruit. Each crop which matures in 60 days since spearing is equal to 21-23 kg and the first fruits are ripe in 45 days.

It is necessary to seriously study the fact that in identical culture conditions tomatoes have a high individual variability concerning productivity. Thus,for an average crop of fruits, close to 650 g.,certain plants produce up to 2700 g. On a square meter of lighting installation, from sowing until harvest, between 25 and 36 plants are cultivated, according to the variety. If each plant produces 2 kg of fruits, the total yield per 1 m2 and per year surpasses 400 kg. and it is even difficult to say if that represents a limit. It is not likely that this is the case, given the fact that a study of potential plant capacities is only beginning !

Pluriannual plants and particularly shrubby species also produce in our lighting installations unforeseesable results. Thus, for example, for grapes, when small cuttings are put in place with a single bud, after four months two bunches of 600 gr. each is obtained. The medical plant of India,Rawolfia, produced in 8 months a quantity of alcaloids, the subject of the culture, equivalent to a 3 year production in Indian plantations.

Thus, artificial lighting allows potential possibilities to appear for any kind of plant species, beginning with annual herbaceous plants and ending with perennial shrubby plants.

The complex and difficult research oriented towards a knowledge of the potential capacities of plants will be undoubtedly profitable, not only due to an important deepening and development of our knowledge, but also by a new method of culture of specially created varieties for an industrial type of horticulture.

One of the essential characteristics of this new horticulture will the ability to obtain, in minimal time, plant products entirely edible and above all without any harmful pollution for man.

XII. PHOTOSYNTHETIC ACTIVITY OF TOMATO PLANTS AT DIFFERENT ROOT SYSTEM TEMPERATURES

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The given paper can be regarded as a continuation of study dealing with peculiarities of function and formation of photosynthetic apparatus in plants under their prolonged growing at different temperature conditions in the root system(14

The problems concerning optimisation of photosynthetic activity have been studied in tomatoes. The light, temperature conditions and some other factors of environment were controlled by the vegetation chamber.

Summary

Under prolonged exposure of tomato plants at bight (35°) and low (15°) temperature, close to optimal one (20-25°), in the root system the following was observed: decrease in rate of NADP photoreduction and Hill's reaction in isolated chloroplats; starch accumulation of various forms of sugars in the leaves and roots ; change in daily equilibrium of carbon; disturbance in the processes of flow and redistribution of assimilates. This results in inhibition of the growth processes and decrease in accumulation of dry weight both in the leaves and a whole plant. At is concluded that temperature in root system required for tomato growth during vegetation is within 20-25°C.

Methods

The tomato seeds (Lycopersicum esculentum), Moldayskije rannije variety, were grown out in the ***cells*** with vermiculite in the vegetation chambers at 40000 ergs/cm2 sec. After the first leaves had appeared the seedlings were placed in onelitre vessels with Knop's nutrient solution. After 6-7 days the plants were placed in the vegetation chambers with root thermostats. Temperature in the root system was automatically controlled: 35,25,20 and 15   1 C. Temperature of the air was 25 at day and 20 at night time. The light intensity at the plant level was about 90000 ergs/cm^2 ***sec.*** The nutrition medium was changed out every three days and pH maintained at 5,5-5,8. For analysis we using the young third or fourth leaves which had just stopped to grow. The testing samples were analysed regarding the physiological age of leaves (2).

The following analyses have been carried out: 1) the rate of NADP photoreduction in isolated chloroplasts (1) ; 2) the rate of Hill's reaction with 2,6-dichlorphenol indophenol; 3)the translocation and distribution of assimilates in the whole plants in phase of 6-7 leaves. The fourth leaf from below had just stopped growing (without separating it from the plant) was placed in the hermetically sealed chamber which was filled then with $C^{14}O_2$. The activity in this chamber was 30 mcC per liter of the medium. The period of photosynthesis was 5 min and that of flow was 6 and 24 **hours.** Then the plants ***was*** separated into five parts: leaf with a label; bottom non-growing leaves; upper growing leaf and apical points; stem; root. The material was fixed at 105° , dried at 40-50° and then grinded. The radioactivity of these preparations (3) was measured in the samples by the beta- particle counter and then recalculated per dry weight of intact organs. C^{14} content in every organ was given in percentage of the initial activity of the leaves; 4) the carbon content in the leaves and carbohydrate content in the different organs of the plant (1).

Results

Temperature conditions in the root system greately has affected the growth and development of both the root itself and everground port of the tomato plant. The dry weight of leaves and stem on the 14 day after factor influence was respectively: 0.57 and 0.21 g at 35°; 0.65 and 0.24 g at 25°; 0.60 and 0.22g at 20°; 0.42 and 0.15 g at 15°. The dry weight of roots was as follows : 0.19 g at 35°; 0.25 g at 25°; 0.22 g at 20°; 0.19 at 15°.

The most high rates of plant growth (in height) were observed at 25° and 20 °. The temperature increase to 35° and decrease to 15° resulted in slow growth of a stem.

So, the temperature optimum in the root system required for tomato growth was within 20-25°. The other temperature conditions proved to be unfavourable for growth and development of the whole plant .

The data on energy metabolism in the leaves (table 1) show a disturbance in photosynthetic activity of a leaf.

Table 1

The rate of NADP photoreduction and Hill's reaction in chloroplasts isolated from tomato leaves grown at different temperature conditions at root

t° C in root system	NADP reduction NADPH/mg chlorophyll A4 mole per hour	Hill's reaction, 2,6 DPIP/mg chlorophyll M mole per hour
35	51.3+ 1.1	241.7+ 1.4
25	70.0 + 1.1	293.4+ 1.4
20	71.5+ 3.6	298.1 + 4.1
15	22.9+ 1.1	205.7+ 3.8

Thus, the activity of photochemical reactions in chloroplasts from tomato leaves is higher at the optimal temperature (20-25°) in the root system than at more high and especially anw temperature of growth. The decreased formation of light stage products in photosynthesis-ATP and $NADPH_2$ had been earlier observed in cucumbers under non optimal temperature conditions at root system (1).11nder such conditions more energy is possibly required for reparation processes (4). Difficulties in energy metabolism cause change in the direction of photosynthetic dark reactions : reduction of carbon dioxide into carbohydrates.

Determination of carbon dynamics in tomato leaves (table 2) showed that the least daily amount of carbon has been shown at optimal temperature of growth in the root system. Under non optimal conditions a considerable amount of carbon is accumulated in the leaves. Data on carbohydrate content in the different plant organs are given in table 3 and proves the results obtained for carbon content in leaves.

Table 2

Carbon daily dynamics and respiration intensity of tomato leaves depending on temperature conditions

t°C in root system	Carbon content (mg/g dry substance) during a day							Respiration, intensity All0 /g raw substance ^{2}
	41	8	12	16	20	24	4_2	
35	21.7	19.7	24.1	19.1	20.1	25.6	23.3	786.6
25	9.5	16.6	13.0	17.5	15.1	13.6	10.8	669.4
20	12.5	20.1	18.4	23.0	16.8	16.8	17.9	720.0
15	21.3	29.9	28.0	26.1	32.6	18.0	17.4	535.0

Table 3

Content of different forms of carbohydrates in different tomato organs depending on temperature conditions (mg/g dry weight)

t°C in root system	Starch	Glucose + Fructose		Sucrose		Sugar(total)
	leaves	leaves	roots	leaves	roots	whole plant
35	10.8+ 0.1	62.5	40.8	50.1 + 1.7	37.4+ 2.0	190.8
25	7.0+ 0.1	47.7	35.8	37.9 + 0.5	27.0+ 1.6	148.3
20	7.3+ 0.0	56.2	34.6	35.6 + 0.8	22.8 + 1.3	149.1
15	12.4+ 0.1	69.9	51.9	52.4 + 0.7	57.9t 0.6	232.1

The lowest content of sugars in the separate organs and plants as a whole is shown in tomato plants at optimal temperature in the root system (table 3). Accumulation of metabolically active monosugars and sucrose in the plant leaves and roots under non optimal conditions is apparently caused by impaired functional activity of these organs. The increased content of total sugar in the leaves of tomato plants with cooled root system is partially due to decrease in respiration intensity of these organs (table 2). According to Dadikin (5) low temperature in the root system results in the delayed sugar flow to the roots. However Andreenko and his colleagues (6) suggest that it can be caused by inhibition of carbohydrates utilization processes which is greater than their formation during photosynthesis. Since we observed sugar accumulation both in the leave; and roots of tomato plants and taking into account the data on assimilates flow from the leaves (table 4) we support the point of view of Andreenko. At the same time the observed redistribution of carbohydrates at high temperature can be mainly caused by a disturbance in assimilates flow-out (table 4). Under non optimal temperature conditions in the root system the starch content in the leaves is increased (table 3). Thin is apparently due to increased polymerization of sugars (7) which are not used in growth.

The great dependence of assimilates flow on plant energetics is shown in the works of Kursanov et al. (8). The disturbance in tomato energy metabolism under unfavourable temperature conditions mentioned above affected the processes of flow and distribution of assimilates (table 4).

Table 4

Flow of C^{14} - assimilates from a leaf and their distribution in plant depending on temperature conditions

T°C in	Radioactivity	percent of total one)			
root system	Leaf fixing C1402	Bottom leaves	Upper leaves	Stem	Root
		6 hour flow			
35	84.13	0.17	5.41	6.21	4.04
25	71.22	0.23	6.03	6.62	15.87
15	68.27	0.26	4.30	9.60	17.53
		24 hour flow			
35	61.77	0.19	12.53	12.17	13.29
25	43.69	0.53	11.49	12.35	31.90
15	42.72	0.30	9.78	11.53	35.63

According to table 4, under optimal temperature conditions in the root system (25°C) 28.8 percent of assimilates flow out of C. The low tempe- a leaf for 6 hours and 56.3 percent for 24 hours. The greatest part of $C^{14}O_2$ fixed by a leaf moves to the root system. The temperature increase in the root system up to 35°C results in inhibition of radioactive carbon dioxide flow : 15.3 percent for 6 hours and 38.2 percent for 24 hours. So, the accumulation of the radioactive label in the root system was considerably decreased. However a flow of C_{lg} - assimilates into upper growing leaves and growth point was nearly the same as for optimal temperature. At low temperature a flow of assimilates from the leaf was somewhat increases (6 hours) or remained the same as under optimal conditions (24 hours). At the same time accumulation of labelled compounds in the roots and decreased flow of C14 - assimilates in the upper growing leafes and growth point were observed. The growth processes of overground part of a plant are really inhibited greater at 15° than at 35° C. The low temprature as it has been already mentioned, greately affected the carbohydrate and energy metabolism and finally accumulation of dry weight.

Thus it can be concluded that the prolonged influence of high and low temperatures in the root system results in impaired photosynthetic activity of tomato plants. The optimal temperature in the root system during vegetation phase for growth and development of tomato plants can be considered within the limits of 20-25°C.

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XIII. A STUDY OF THE KOK EFFECT ON THE LACTUCA SATIVA CV. ROMANA

x

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Summary

The Kok effect has been studied in *Lactuca sativa* cv. Romana. The experiments were carried out at 25°C with leaf disks or with mesophyll fragments floating in the distilled water. The measurements were carried out with a IRGA appared in a closed system. It has been observed that the Kok effect, which is independent of stomatal aperture, disappears in an atmosphere at low 0_2 content while is more pronounced in

an oxygen atmosphere. Moreover, it is not observed in plants kept in darkness for 48 h.

The variation of the Kok effect with respect to the oxygen quantity as well as with respect to the duration of the previous photosynthesis suggests that the amount of photosynthetis is the determining factor for the occurence of the Kok effect.

Introduction

The sharp change in slope of the gradient, produced at low energy level in the relation between net photosynthesis and light intensity is called "Kok effect" (KOK, 1948, 1951).

The starting of the photorespiration may be responsible for this phenomenon (DECKER 1957; HOCH, OWENS and KOK 1963; CORNIC and JARVIS 1972) : in fact, a considerable increase of CO2- influx beyond a certain energy, would lead to a diminution of the observed net photosynthesis thus a change in the characteristic slope. The Kok effect has been observed particularly in the algae (RIED 1970).

Few authors have reported its occurence in the higher plants; VAN DER VEEN (1949) and DECKER (1957) have shown it in tobacco leaves.

CORNIC and JARVIS (1972) ,EL AOUNI (1973) observed the Kok effect respectively in *Picea sitchensis* and *Pinus nigra.* The present research was undertaken in order to determine whether there existed a close relationship between photorespiration intensity and Kok effect and to define the conditions under which it can be observed.

Material and Technique

The plant used was *Lactuca sativa cv. Romana.* Its culture was done under controlled conditions in the Phytotron of C. N. R. S., in Gif-sur-Yvette.

During its growth the temperature was maintained constant at 22°C and the relative humidity at 70% ; the incident energy in the visible waveband was of about 400 microE m-2 sec^{-1}. The manipulations were made in plants about 35 days old : they carried out in the foliar disks of firts five leaves. The measurement of COexchange was carried out in the infrared by ONERA analyzer mounted in a closed system of 2.6 1. h^{-1} volume.

The assimilation chamber, in which the leaf disks were let float in the surface of distilled water,was connected with a thermostat. The temperature during the manipulation in the leaf disks was maintained at 25 + 0.5°C.

The illumination was carried out with two mercury vapour lamps "Mazda DADF 90", 440 w.

The energy in the visible Waveband was measured with a quantum- meter lambda. The value of the net photosynthesis could be evaluated in normal air, or in an atmosphere at low O_2 content (about 1%) , or in high O_2 content (about 99%).

In the latter two cases a known quantity of carbon dioxide gas was added by a syringe after having filled the measurement circuit, with one of the two gases. The measurement of the photosynthesis was done the CO2 concentration in the atmosphere had reached the value 290 vpm.

Results and Discussions

I. The variation of the Kok effect with the O2 content of the atmosphere

Figure 1 shows the variation of the net CO, exchange as a function of the 02 content of the atmosphere (1,21,99%) ,and of the tow light energy level. The plants had been illuminated for 7 hours before the manipulation. Each curve represents the mean value of gaseous exchange for five plant. It can be seen that the Kok effect is well evident in the atmosphere at 21% and 99% 0_2 content. In the former case the change in slope of gradient takes place at about 27/4Em^{-2}sec^{-}I, while in the latter at about 14/11Em^{-2}sec^{-1}. In a 1% Oxygen atmosphere, on the other hand, Kok effect is only hardly evident.

The value of the Kok effect can be determined by the ratio between the two parts of different slope which can be seen in Fig. I . Thus, the Table 1 shows that its value in 99% 0_2 atmosphere is twice that in 21% 0_2. The Kok effect is, therefore, more easily observed in an atmosphere with high 0_2 concentration. This finding is analogous to that observed by CORNIC and JARVIS (1972) in Picea sitchensis.

We wanted to find out the extent to which the stomatal opening could influence the occurrence of the Kok effect. Fig.2 shows the effect of the light on the net COexchange, measured in 21% 0_2, in the leaf fragments floating the upper surface in the water and the Tower epiderm had been ken away. The Kok effect is observed: the change slope takes place at about 29 microE m^{-2}sec^{-1} , a value close to that observed in 21% 0_2 (Fig.1).

The variation of the stomatal opening does not influence the occurrence of the Kok effect.

The Kok effect variations are therefore parallel to that of the photorespiration ; it is known, in fact, that the latter is inhibited in an atmosphere at low 0 concentration and is maximum in 100% 0, (see for example the review by JACKSON and VOLK 1970). One notices moreover (Fig.1) that the respiration is very much affected by the oxygen concentration in the atmosphere in 1% 0_2 it is highly diminished.

Table 1

Effect of O2 concentration on the Kok effect value (K). K is measured by the ratio between the two parts of different slopes which constitute the occurrence of the Kok effect.

	21% 0_2	100% 0_2
Effect Kok	2,8	5,4

Fig. 1

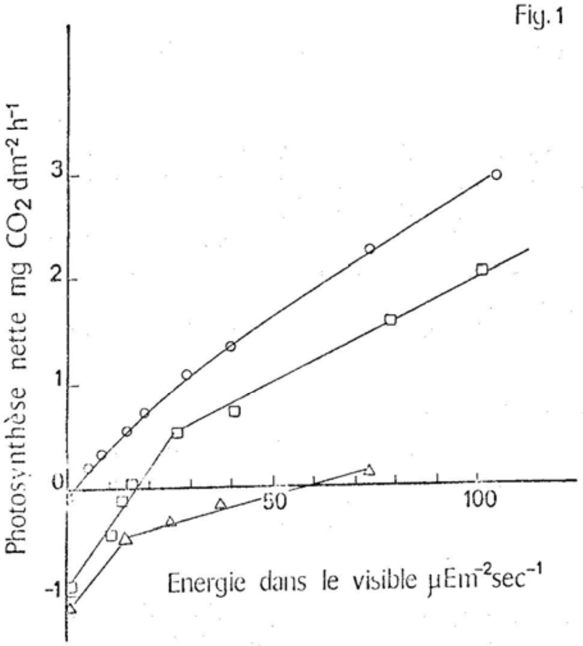

Fig.1.The relation between net photosynthesis and incident energy. The measurements were carried out with leaf disks whit the upper surface floating the water,in an atmosphere containing 1% (o——o), 21% (□——□), or 99% (△——△). Each curve represents the mean value for five plants.

Fig. 2

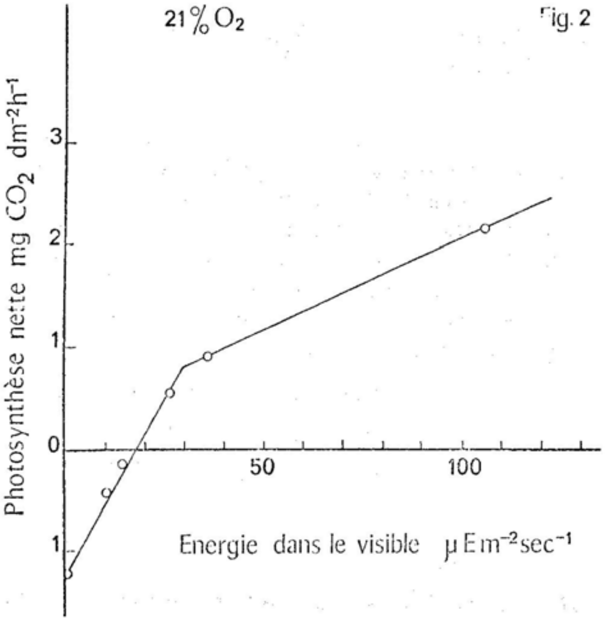

Fig.2. The relation between net photosynthesis and incident energy. The measurements were made with leaf fragments with the upper surface floating in the water;their lower epiderm is had been taken away,-21% d'O_2 concentration in the atmosphere.

Fig. 3

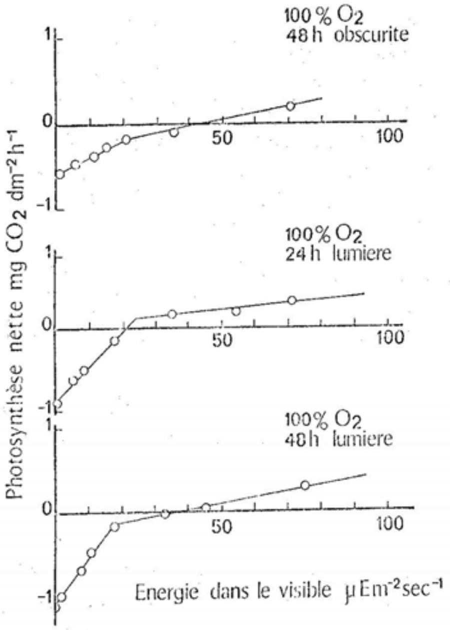

Fig.3. The relation between net photosynthesis and incident energy.The measurements were made, in an atmosphere containing 99% O_2,with leaf disks floating on the water.
Measurements made after 48h of darkness (fig.3a),after 24h (fig.3b) and 48h of illumination (fig.3c).

II. Variation of the Kok effect with the length of the previous Photosynthesis Period.

The net CO2 exchange was measured as a function of the light energy on the plants kept respec tively for 48h in darkness, and then 24 and 48h under continuous light. These manipulations were done with five plants. From the leaves of each plant foliar disks are taken out and they are treated in the manner as described above. The measurements are carried out in 99% O2 condition under which the Kok effect is easily observed. The results obtained are shown in Fig.3. It can be seen that after 48h of darkness the Kok effect is low,while after 24 and 48h of continuous light is well evident.

With a maximum value after 24h (table II).

The table II shows also the photorespiration variations measured by the CO2 - efflux in an atmosphere free from CO2 and the CO2 compensation point.

Table II

Effect of the illumination period on the Kok effect,value : and on the CO_2- efflux in the light, and the CO_2 compensation point measured under an energy of 100$_1$14 Em^{-2}sec^{-}1. 0_2 concentration 99%.

Treatment	K	Photorespiration	vpm
48h darkness	2.5	1.2	160
24h illumination	12.8	3.3	200
48h illumination	6.2	2.4	230

In both cases the measurements were made under an energy of 1000 microE m-2 sec-1, and in an atmosphere containing 99% oxygen. It is seen that the photorespiration passes through a maximum after 24h of continuous light; Ludwig KROTKOV and CANVIN (1969) observed an analogous result with Helianthus annuus. It reaches,on the other hand, the highest value after a continuous illumination of 48h. The latter observation shows that, perhaps, a decrease of photosynthesis then takes place; the increase,in fact, is not attributable to the CO_2 efflux value in light, which is less than observed after 24h of continuous light.

The lowering in the photosynthetic activity causes a decrease in the photorespiration because these two phenomena are interrelated, (TOLBERT 1971). As is evident from the Fig.3, the respiration increases regularly with the duration of the illumination.

The Kok effect value is therefore related to the intensity of the photorespiration. It is seen moreover that after a period of darkness it is hardly observed.

Conclusions

The results described above show that the Kok effect value varies in the *same* manner as the photorespiration intensity. In fact,like the photorespiratory activity, the occurrence of the Kok effect is related to the O2 concentration in air. Moreover, when the value of the previous photosynthetic period is increased, a parallel variation in these two phenomena is observed.

It is well evident that the intensity of the photorespiration is an important factor for the occurrence of the Kok effect. According to this hypothesis, the sharp change in the slope of gradient in the relation between the net photosynthesis -light energy, implied by it, may indicate that a minimum energy is needed for the start of photorespiration, this is in agreement with previous observation (CORNIC 1970).

In the cases where the Kok effect could not be observed, it is possible that the previous photosynthesis period had been probably insufficient.

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XIV. THE KAZAKSTAN PHYTOTRON I

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The wide spaces of Kazakstan, with its many different climatic zones as well as soils, require very different approaches for solving problems concerning the increased productivity of plants.

In planning the first artificial climates installation for the Botanical Institute of the Academy of Sciences in Kazakstan (in Alma Ata), we attempted to use apparatus and material either existing on the national market or to have them specially built for us. Among the latter are found a YIK-3M artificial climate installation,a K -1 static growth chamber and a YCK-1 dry wind climatic installation. By means of these installations,tenperature,air humidity and wind velocity can be regulated and light intensity and quality can be modified. Artificial dryness of the soil or of the air can also be created, and plants can be submitted to the effects of frosts and dry winds of varying intensities and lengths.

At this time the climatic installations of the laboratory are in full activity.

The YIK-3M artificial climate installation maintains in a room (15 m3) climatic conditions on a 6 m2 surface chosen within the limits :

-Temperature : -15 to + 60 °C
-Relative humidity : 30 to 98%
-Lighting up to 80 000 lux

Variations of day-night conditions can be realized automatically. The lighting is made up of incandescent lamps with reflectors, above a water filter assuring within the room a luminous intensity and a spectrum which is close to that of solar lighting.

The K-phi-1 static growth chamber is designed to maintain in a closed environment the given parameters for temperature,lighting,humidity and air composition :

The technical characteristics are:

-volume of work : 2 m3
-temperature adjustable between -15 and + 50°C with a volume gradient of
+ 0.5 C and a precision of + 0.5 C

-culture surface: 1.2 m2 -the plants are cultivated by hydroponics or aero-
ween -1 and + 50°C with a precision, in the root volume of + 1°C.
ponics . Temperature adjustment of the root environment by thermostat
bet-Intervals for watering plants adjusted automatically :

a) in aeroponic conditions between 5 and 30 minutes
b) in hydroponic conditions between 30 minutes and 24 hours

-Relative humidity adjustable between 40-90% with a precision of 3 to 5% RH.

- CO2content maintained within the following limits:
a) with admission between 0 and 1%
b) without admission between 0 and 0.1%

-Maximal lighting : 50 000 lux on the culture surface
-Automatic change between day and night for light and correlatively for temperature and humidity.

A main principle for the dry wind climatic installation (described with the corresponding license under the heading "Climatron", 3.17.1972,Number 341445, jointly signed with B. V. Czepetkin of the "Agropriboe' interrepublican Union in Moscow) is the regular ventilation of air in motion on plants. (See table and figure).

Inside the growth chamber (1) made of insulating thermic material,and with windows (2) allowing the introduction of plants for experiments, there is a rotating table (3) with feed motor (4). The table is fitted with mobile trays for the plants, ensuring their regular ventilation.

On the periphery of the table are set out trays or plates (5),which receive the growing pots with the plants; they move around their axis during the rotation of the whole table,which avoids unilateral wind action on each plant. In the corners of the growth chamber ventilators (6) with deflectors (7) are set out around the table, oriented towards the plant along the tangent of the circumference of rotation.

The ceiling of the chamber is made up of a box with metallic walls (8) and a glass bottom in which is put a layer of water (9). Above this box lighting lamps (10) are set out. The chamber is equipped with an air conditioner with refrigeration (11) and heating (12).

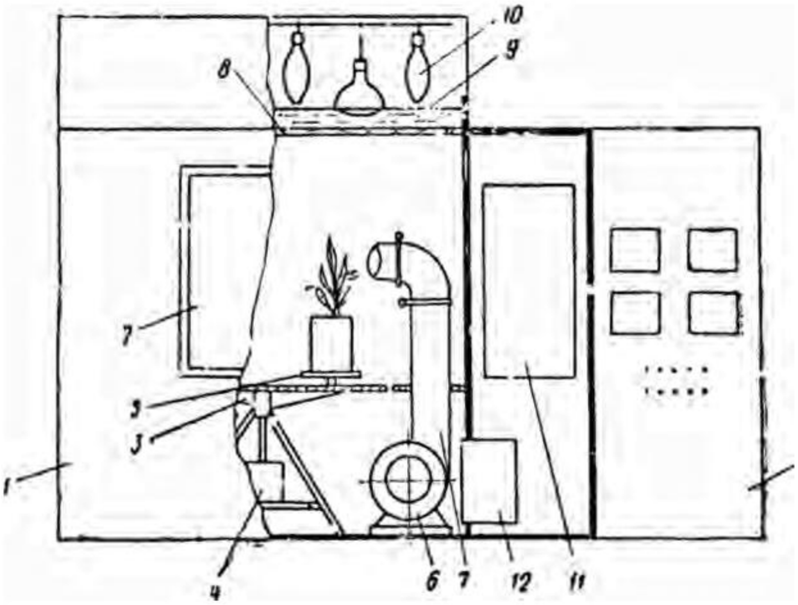
A regulation panel (13) completes the installation with automatic control and programmed regulation apparatus for the air parameters of the chamber.

By means of a regulation panel and apparatus which are placed on it, the system for programming and regulating the parameters chosen for temperature, relative air humidity are set in motion, as well as setting in motion the ventilators and switching on the lamps. As soon as the required conditions for air parameters are attained in the interior of the chamber,and which are close to dry wind climatic conditions,the experimental plants are placed on plates,and rotation of the table is set in motion.

The rotation of the plants on the circumference with a successive passage of the deflector's zone of action into that of the next, produces a continuous effect of wind action on the plants and assures a uniformity of ventilation for all the plants.

By examining the plants' reactions in a chamber so ventilated, adaptation mechanisms can be analyzed and modifications can be found which provoke a decrease of plant productivity. The quality of new varieties can also be studied in respect to those existing and thus their possibilities for actual adaptation, in regions of production where meteorological conditions are known, can be established.

In our Phytotron we also have greenhouses with a DKCTB-6000 artificial lighting installation, with a system for the preparation and distribution of a nutrient solution in thermostated hydroponic baths, an installation for air conditioning,a control and measuring apparatus for recording and regulating the physical and chemical parameters of the aerial and root environment (temperature,humidity, lighting, pH,etc..). Moreover, the Phytotron has at its disposition numerical and analogic computers, and a modern electric appaatus making it possible to continue doing research on various biological phenomena using a relatively wide range of possibilities.



Principle of the dry wind climatic installation of the Phytotron of Botanical Institute of Kazakstan Academy of Sciences.

TABLE

Main technical characteristics of the dry wind climatic installation in the Phytotron of the Botanical Institute of the Academy of Sciences in Kazakhstan.

Name	CY-1 dry wind installation
Purpose	To study the resistance of plants to dryness of the air
Usable volume of chamber	2.88 m3
Plant surface	3.2 m2
Light source	3H-1000, DP-1000 Lamps
Parameters for air regulation	
Temperature	between + 10 and + 50°C
Relative humidity	between 15% and 50%
Luminous intensity	up to 40 000 lux
Wind direction	Mixture between : from top to bottom and ascensional laterally
Wind velocity	between 3 and 15 m/sec.

Taking into account the climatic "contrasts" of the territory of Kazakgtan, the activity of the Phytotron, since its founding, has been orientated towards finding means of increasing plant resistance to unfavorable conditions. This research has been followed along two lines which are mutually complementary, which,on the one hand, demonstrate the reaction of plants to extreme conditions,and on the other hand,the active regulation of growth and productive processes of plants, particularly the principal cultures which characterize botanically our Republic: winter wheat and spring wheat.

Research in this area has centered mainly on problems of resistances to cold, to dryness and heat, on the hydric regimen,on the intensity and productivity of photosynthesis,on the character of metabolic variations, on the physiologic particularities of species and genera of wheat, on the maturation of seeds,and on the action of activators and inhibitors of growth. Tests were done which make it possible to make rather broad generalizations and to draw conclusions about physiological properties and the functional activity of the principal organs of the plant and the whole plant in various culture conditions,as well as in regularizing vital processes by physiologically active substances. In addition to its theoretical orientation, this research was of practical use in the selection and culture of wheat and other species.

Taking as a basis the experiments carried out, physiological models of varieties were able to be determined,with the aim of actually realizing and integrating them in programs for the selection and creation of new high yield varieties.

The results obtained have served as a basis for work on improvement and creation by breeders in Northern and Southern Kazakstan (V. P. KUZMIN , N. L. UDOLSKI and others)to obtain ecological types of wheat adapted to local conditions. In this way,interesting and promising kinds and forms have been created which support periods of drought in the spring and summer in a particular manner -by checking growth processes during dry periods, in limiting water losses and in activating assimilating functions of the upper leaves where growth takes place precisely during the most favorable period with sufficient humidity. Taking as a basis research by physiologists, the coefficient of the useful activity of each variety has also been particularly studied, as well as the integration and the energetic participation of all the aerial organs (including the ears, the glumes and the seed during growth) in the unitary process of the creation of plants yields.

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XV. CONFORMATIONAL FLEXIBILITY OF PROTEIN MOLECULES AND ADAPTATION OF PLANTS TO THE TEMPERATURE OF THE ENVIRONMENT

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Adaptation of organisms to the environmental temperature is achieved through various mechanisms which belong to all levels of organization of the living, ranging from the molecular level to the biocenotic one. That has enabled living organisms to inhabit practically all of the climatic zones on our planet. Adaptations to the environmental temperature,seen at the higher level of organization of the living, may differ even in taxonomically related organisms. They are absolutely different in plants as opposed to those in animals. On the other hand,the principles underlying adaptations to temperature at the cellular, and,in particular,at the molecular levels, are of more universal nature and may be similar in plants,animals and bacteria.

This paper deals with an hypothesis which states,that for organisms to adapt to the environmental temperature,it is of primary importance that a definite correlationship be maintained between the level of conformational flexibility of protein macromolecules and the temperature conditions of a species existence, during an active period of life of organisms (ALEXANDROV 1965,1967,1969,1975). This hypothesis pretends to be applicable to all organisms. That is why I will, of necessity, refer also to the data on bacteria and animals.

Formulation of this hypothesis has been suggested by the following observations:

I. In hundreds of bacteria,animal and plant species,it had been shown that homologous cells of more thermophilic species displayed higher thermostability. In plants, this had been demonstrated in algae, lichens,mosses and flower plants.

One should discern the primary and general thermostability of cells. We designate the primary thermostability as that which is evaluated immediately following short-term intensive heatings. In this case , the destructive afteraction and repair of the thermal injury had not yet time to develop. The general cellular thermostability is assessed either after prolonged moderate heat treatments or in delayed periods of time,after the end of a heat exposure. The general thermostability is a complex result of the primary thermal injury, the destructive afteraction and reparatory activity of the cell.

The numerous data,concerning the parallelism between thermophily of a species and the primary thermostability of cells,are important for substantiating our hypothesis. The fact is, that the primary thermostability of cells is determined by the resistance to thermal denaturation of those proteins, which are associated with the function,chosen as indicative of the cellular heat stability. This contention is validated by vast evidence accumulated to this data. Therefore, the primary thermostability may be used as an indirect criterion for comparing protein thermostability in different cells.

The existence of this parallelism indicates that in the evolution a correlationship has been maintained between the thermostability of cellular proteins and the temperature conditions of a species existence.

2. In favour of this view,one can present also direct evidence,demonstrating higher thermostability of homologous proteins in related species exhibiting greater thermophily. The majority of pertinent findings have been obtained in bacteria and animals. In many cases, it has been shown that thermostability of enzymes in thermophilic bacteria and algae by far exceeded that of homologous enzymes in mesophilic organisms. Psychrophilic organisms, in their turn, possess enzymes, which exhibit very low thermostablity. A large body of evidence can be presented on this correlationship also in almost all types of animals: Worms, Mblluscs, Artropoda, Vertebrates. Here is but one example: more than 15 proteins have proved to be more heat resistant in the southern lake frog Rana ridibunda as compared with those in the grass frog R. temporaria,the latter living farther to the North. So far,the data of this sort are scarce in plants. In our laboratory, we have studied in detail two species of the snowflake Leucojum vernum L. and a more warm loving one -- L. aestivum L. In L. aestivum, a number of cellular functions have proved to exhibit higher thermostability (the protoplasmic streaming, photosynthesis, respiration, capacity of *cells* for

plasmolysis),as well as some proteins (water soluble proteins,dehydrogenases,tested by their capacity to reduce tetrazolium salts,ferredoxin,pyrophosphatase, beta-glycerophosphatase and urease) (table).

Considering the observations concerning the primary thermostability of cells and the heat resistance of proteins, one should regard as proven the existence in nature of a correlationship between the level of thermostability of proteins and the temperature conditions of a species life.

3. Arguments can be easily provided in favor of the view,that the level of thermostability per se may is of no adaptive significance. Referring to only one of these, it might be indicated that comparing thermostability of proteins in closely related species differing in thermophily, a corresponding difference may be observed both in thermolabile proteins and in extremely thermostable ones,which are not involved in determining the resistance of an organism to heat. Thus, for example, adenylate kinase in the grass frog is half denatured by a 30 min heating to 62°whereas this enzyme isolated from the lake frog - at 73. In the spring snowflake, pyrophosphatase is 50% inactivated by a 30 min heat treatment at 62°, and that in its summer counterpart- at 75°. Neither frogs, nor snowflakes never have been exposed in their life to everheatings of this magnitude. It is obvious that adenylate kinase is in no way responsible for thermostability of frogs, same as pyrophosphatase is not critical for the heat resistance of the snowflakes. Therefore, if the interspecific difference in thermostability of proteins is a consequence of the selection of organisms,that occurs not because the levels of thermostability of these proteins bear any adaptive significance. It must be admitted, that the level of protein thermostability is inseparable from some an other parameter of a protein macromolecule,which, at normal temperatures, is of vital importance for organisms and,therefore,is controlled by the natural selection.

4.1 believe that this parameter is the conformational flexibility of the protein macromolecule . It has been firmly proven by now,that most proteins performing their functions undergo conformational changes,involving the secondary,tertiary and quartenary structure. It is in this regard that the conformational flexibility,as justly indicated by Koshland, is thought to be the most important characteristic of protein macromolecules. The level of conformational flexibility must be sufficient for realization of conformational transitions,but it should not be excessive. Endowed with excessive flexibility, the macromolecule would not be able to retain the required conformation. In other words, the protein macromolecule must be in a semi-labile (or semistable) state. The conformational flexibility of protein macromolecules is a temperature-dependent variable. Flexibility grows as temperature increases. Therefore,an adaptation to an elevated temperature should be accompanied by a decrease in the conformational flexibility ; conversely, an adaptation to a low temperature is to be expressed in an enhancement of the flexibility. A decrease in flexibility is achieved through strengthening of the bonds and interactions supporting the secondary, tertiary and quartenary structure of the protein macromolecule. Concordantly,this will enhance the resistance of proteins to the denaturing action of heat . Weakening of these bonds results in augmentation of the conformational flexibility, that must be manifested in a decrease of the thermostability of the molecule. A change in the flexibility of protein may be achieved either at the expense of an appropriate substitution of amino acid residues in the macromolecules or through modification of their association with ligands. Independently of the means by which a change in the level of conformational flexibility of proteins is achieved, an increase in flexibility would result in a decrease of the protein resistance to the denaturing action of heat, and augmentation of the molecules's rigidity would be expressed in an elevation of its thermostability. In sum,we should regard the difference in the primary thermoresistance of cella and in the heat-stability of proteins in species differing in their thermophily, as an indirect proof for the existence of a difference in the conformational flexibility of proteins in these species.

Consequently, based on the evidence accumulated in cyto-and molecular ecological studies,we may conclude that in the process of evolution there is maintained a correlationshiy between the level of conformational flexibility of proteins and the temperature conditions of a species existence during an active period of organism's life. As a consequence, there is a correlation between thermophily of a species and thermostability of its cells and proteins.

5. Apart from thermostability, a sensitive, albeit also an indirect, indicator of the level of conformational flexibility of protein macromolecules, is the resistance of proteins to proteinases. It might be expected that proteins of more thermophilic species are more stable not only to heat but also to the digestive action of proteolytic enzymes. Unfortunately, investigations along these lines have not yet been performed in plants, however, for animal proteins unambiguous data have accumulated. It has been shown in our laboratory, for example, that collagen,serum albumin,myosin, adenylate kinase proved to display higher resistance both to heat and proteolysis in the southern frog Rana ridibunda as opposed to that in the northern Rana temporaria. It is time to conduct similar investigations also with plant proteins.

6. As pointed out above,from the hypothesis of the necessity of maintaining protein macromolecules in a semistable state,it obviously follows that an adaptation to elevated temperature requires an increase in rigidity of protein macromolecules takes place. Similarly, during adaptation to lower temperatures,it is essential to diminish excessive conformational rigidity of proteins. The level of rigidity ,inappropriate at a given temperature,must be eliminated by the selection. The latter acts on the organism. In this connection, a question arises what negative consequences for the organism's life might follow from alteration of the correspondance between flexibility of proteins and the environmental temperature. At this time, I can point out two of these consequences which might evoke interference of the selection.

7. The literature is abundant with data on the temperature dependence of the rate of various physiological and biochemical processes in organisms adapted to different temperatures. The plots,depicting this dependence, are usually of the dome like shape and the zones of minimum, maximum and optimum can be clearly seen. It is believed that the slope of the curve between the minimum and optimum is determined by the activation energy of the process. The abruptness of the curve between the optimum and maximum depends on the rate of thermal inactivation of the enzymes involved. The fig.1 shows the curves,reported by SANDO and HOGENKAMP (1973),for the effects of temperature on the activity of ribonucleotide reductase isolated from the thermophilic bacterium Thermus X-I and from mesophilic Lactobacillus leichmanii. The enzyme from the thermophile is considerably more thermostable and the maximum zone is shifted to the right by 20° in comparison with the position of the maximum in the curve for the mesophile. This can be readily understood. What is important, however, is that the thermostable enzyme proved to be practically incapable of performing in the zone of lower temperatures which correspond to the temperature optimum for functioning of the mesophilic ribonucleotide reductase. I believe that the dramatically lowered activity of the thermophilic enzyme in this zone is due to insufficient conformational flexibility of the enzyme. Inability of the mesophilic enzyme to function at temperatures optimal for the thermophilic enzyme is associated with its excessive flexibility that results in alteration of the native structure a the enzyme at such a high temperature. If adaptation of an enzyme to functioning under new temperature conditions is achieved by means of an appropriate change in the level of its conformational flexibility, this adaptation should result in a lateral shift of the whole

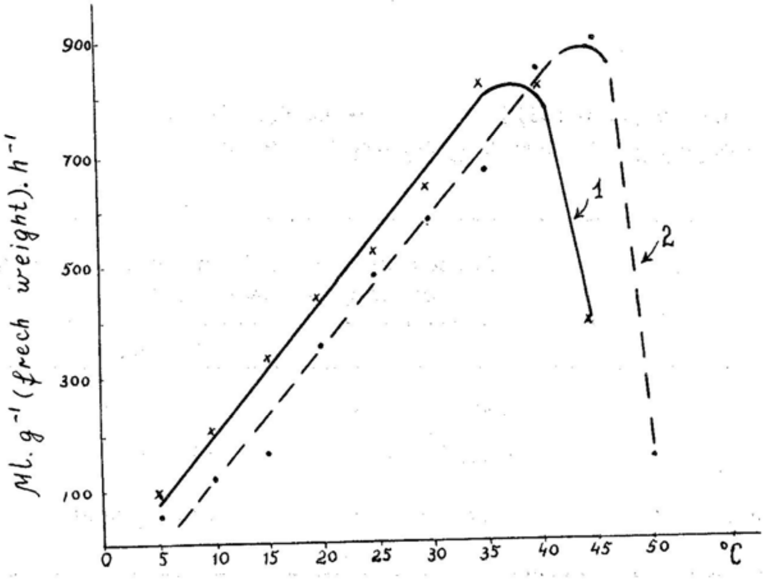

Fig.1. The temperature dependence of ribonucleotide-reducase activity from the thermophile Thermus X-I (I) and the mesophile Lactobacillus leichmanii (2) (Sando and Hogenkamp, 1973).

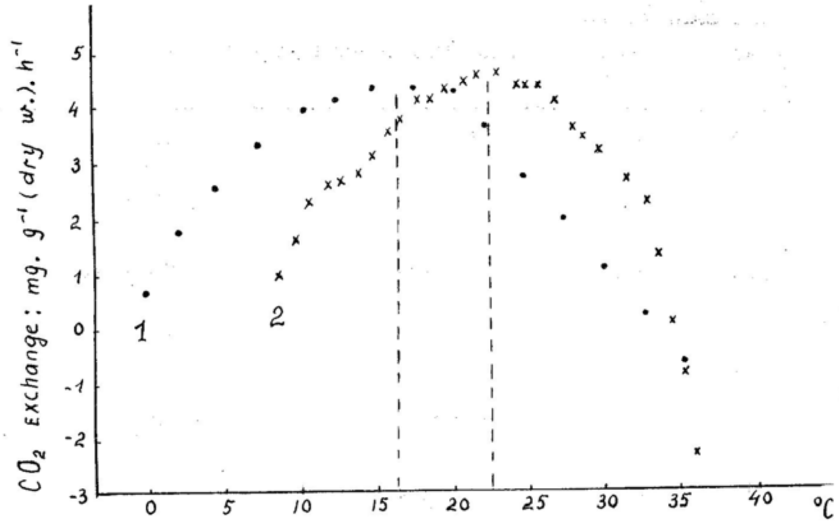

Fig.2. The temperature dependence of CO_2 exchange of Cladonia rangiferina (1) and C. subtenuis (2) (The date from Adams 1971 and Peet and Adams 1972)

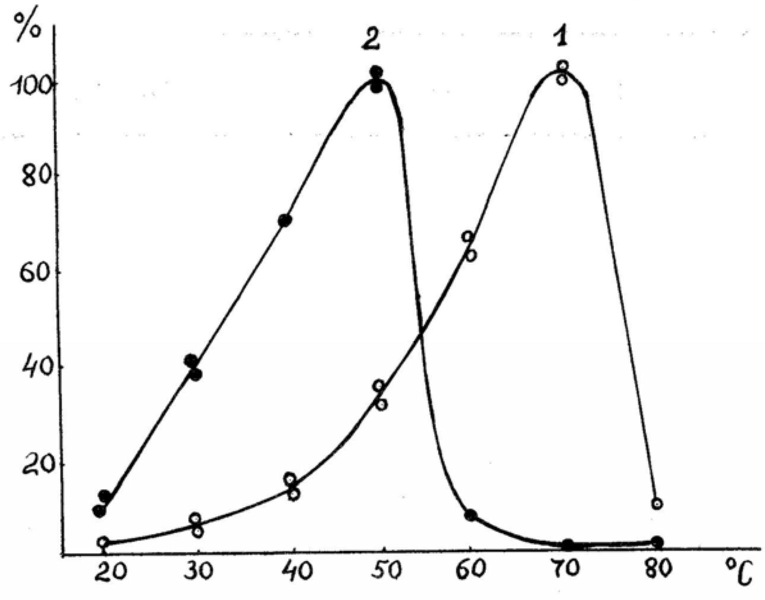

Fig.3. The temperature dependence of respiration in leaves of Primula tschuktschorum (1) and P. denticulata (2) (The experiments by M.D. Vaskovshy).

Differences in the thermostability of various functions
in the Leucojum vernum L. and L. Aestivum L. leaves

Test	Temperature of a 5-min heat treatment suppressing a function : L. Vernum	L. Aestivthn
Protoplasmic streaming	44.6 + 0.1	46.1 + 0.1
Capacity for plasmolysis	52.6 + 0.3	55.3 + 0.5
Reduction of tetrazolium salts	55.7 + 0.3	58.0 + 0.0

Test	Heat dose time (min)	t-re (°C)	Residual activity (%)	
Photosynthesis	10	44	25 + 2	37 + 3
Respiration	5	55	17 + 5	46 + 3
Ferredoxin activity (in leaves)	15	48	47 + 5	83 + 10
Pyrophosphatase activity (in leaves)	30	55	51 + 2	67 + 3
Pyrophosphatase activity (in homogenate)	30	50	62 + 5	75 + 3
lS-glycerophosphatase activity (in leaves)	30	55	46 + 4	71 + 6
Urease activity (in homogenate)	40	80	41 + 4	55 + 4
Extractibility of proteins (% of control)	30	55	27 + 3	57 + 11

curve. Adaptation to elevated temperatures will transpose the curve to the right, while adaptation to cold will shift the curve to the left. In fact, we can find in the literature a multitude of pertinent examples for microorganisms, animals and plants differing in their thermophily. Ample experimental evidence is available indicating that growth processes,photosynthesis, respiration and so on, proceed at a lower rate at lower temperatures in more thermophilic species. Another two examples Fig.2, taken from the works of Adams (ADAMS 1971; PEET and ADAMS 1972), illustrates the curves for the temperature dependence of net photosynthesis in two lichen species Cladonia subtennis and Cladonia rangiferina. The area of Cladonia rangiferina is farther to the North. Fig.3 gives the temperature dependence of respiration for two Primula species: Primula tschuktshorum and the more thermophilic southern species-P. denticulate. These data have been obtained by my colleague Vaskovsky. The vast body of evidence, obtained in plants and other organisms warrants, contention that loss of the correspondence between the level of conformational flexibility of protein macromolecules and temperature conditions brings about an alteration of the normal dependence of the rates of biochemical and physiological processes on temperature. This event may be enough provocative for the interference of the natural selection to take place, and,thus, for elimination of any deviation of protein macromolecules from their semistable state.

8. The second indication for the regulation of the semistability level of proteins by the natural selection is as follows. It is known, that the protein content in the cell is conditioned by the ratio of the rate of its synthesis and degradation. Any protein is characterized by a specific duration of its half life. The latter may vary appreciably in different proteins from minttes to days. This problem too has attracted much greater efforts in animals and microorganisms than in plant studies. It is of interest that the rate of protein degradation depends on the resistance of proteins to proteinases. Earlier I said that the resistance of proteins to proteolytic digestion as well as to the denaturing action of heat varies as a function of conformational flexibility of protein macromolecules. Accordingly, the level of conformational flexibility must influence the rate of protein degradation. Disbalance of a required correspondence between flexibility and temperature will necessarily unfavourably affect not only protein activity, but will also interfere with the normal rate of its degradation. The latter, in its turn, must adversly affect regulation of protein content in the cell. It is justified to believe, that deviation of the rate of protein degradation from the norm may too serve as a trigger for interference of the natural selection. It is highly likely, that a shift of the conformational flexibility of proteins from the optimal level,produced by variations in the temperature conditions of a species life,results also in other adverse consequences for life of the organism, which also become acted upon by the natural selection.

9. By what means the conformational flexibility of proteins is changed in the evolution during adaptation of a species to new temperature conditions? It is extremely difficult to provide answers to this problem at present. Presumably, in order to bring the level of conformational flexibility of protein macromolecules into a correspondence with the environmental temperature, both in phylogenesis and in individual life,the Nature follows two major routes: I) modifying the primary structure of proteins ; and 2) modifying their association with ligands.

Further research on this problem, to my mind, is of general biologiCal importance since, in the rich armameatarinm of devices, by which organisms adapt to the environmental temperature, the regulation of the level of conformational flexibility of protein molecules occupies a central position.

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XVI. THE USE OF NUMERICAL CLASSIFICATION IN THE ANALYSIS OF VEGETATION / ENVIRONMENT RELATIONSHIPS

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Vegecation comprises a plant/environment complex which may for the purpose of analysis be conceived in terms of a multivariate system. Within this *system* a number of attributes relate exclusively to the plant component of the vegetation and a number to the physical environment of these plants. For the purpose of the present contribution discussion will be confined to floristic units of the plant component, i. E. Species, and those environmental features which affect plant distribution and growth. Thus the system comprises two essential parts- a plant component and a habitat component. Since both floristic and environmental features are recorded as attributes of particular spatially defined sites, these sites form the link between the two components. The complete system therefore may be regarded as a plant/site/habitat complex (LAMBERT and DALE 1964).

Particular interest resides in the multivariate interactions between the various elements of this system rather than in its univariate parts,and multivariate numerical techniques will be required to simplify the system for description and abstraction. However,the plant and habitat components present rather different problems for analysis. The species which are present at the site are compatible in unit of measurement and kind,and the problems that require consideration relate to the actual form of measurement to be used and the biological nature and ecological usefulness of the information obtained. In contrast, the environmental attributes used to characterise the sites are likely to be different in kind and in their unit of measurement, and primary problems are related to the selection of features for sttdy and their numerial behaviour (LAMBERT and DALE 1964; CIPRA et al.1970; GOLDSMITH 1973).

With these points in mind decisions must be made as to whether it is desirable for the purpose of analysis to treat the system as a single and integrated plant/site/habitat matrix,or whether the plant and habitat components should be separated at this stage. In the former case interest would reside in primary correlations between the various element. T. of the integrated matrix; in the latter each component would be investigated in its own right and correlations between the two sought secondarily. Whilst the first approach *is* philosophically attractive,since vegetation is rarely conceived without reference to its environment, in terms of numerical analysis the results are likely to be difficult to evaluate (WILLIAMS 1971a). The second approach is therefore more desirable. The system may then he redefined to give two separate complexes (fig.1), one pertaining to the site/plant reLationships and the other to site/habitat relationships.

Further decisions at this stage will be concerned primarily with the type of analysis that is required. In general,multivariate structuring techniques which reduce dimensionality and reveal pattern in the data are most useful. Techniques of this nature fall essentially into two groups: those which structure the whole population of sites simultaneously along different lines of variation, and those which use this variation to erect sub-divisions of the population into a number of more homogeneous groups. Examples of the former approach are provided by the various methods of intrinsic ordination (DAGNELIE 1960; ORLOCI 1966) and of the latter by methods of intrinsic classification (CORMACK 1971; WILLIAMS 1971b). Bearing in mind that the ultimate aim of the exercise is to examine the relationship between plants and their environment, techniques which subdivide the population have certain advantages. Firstly, the nature of the system is such that both linear and non linear relationships within and between the plant and habitat components may be expected (GOODALL 1954; GROENEWOUD 1965). Whilst linear relationships can be effectively elucidated by existing techniques, non linear relationships pose particular problems (SWAN 1970; AUSTIN & NOY-MEIR 1971; BEALS 1973). Such difficulties may be minimised by the use of classification, since approximation to linearity is likely to be greatest in fairly homogenous data i. E. In sub-sets of markedly heterogeneous populations (AUSTIN et al.1972) . Secondly, whereas certain environmental features may be expected to exhibit effects over the entire population, others may be concerned only with specific sections. Classification offers a means by which both effects may contribute effectively to the analysis.

Hierarchical classifications are most useful in this context. Since sub-populations are produced in a sequential manner, the total population at one level becomes a series of sub-populations at another. Hence factors operating across the total population can be investigated in the first instance and those affecting primarily a given sub-population in the second. The most powerful hierarchical techniques are

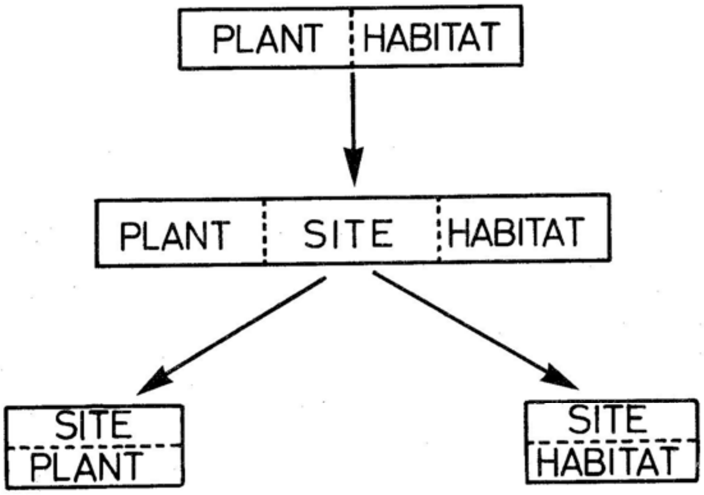

Fig.1. The vegetation complex

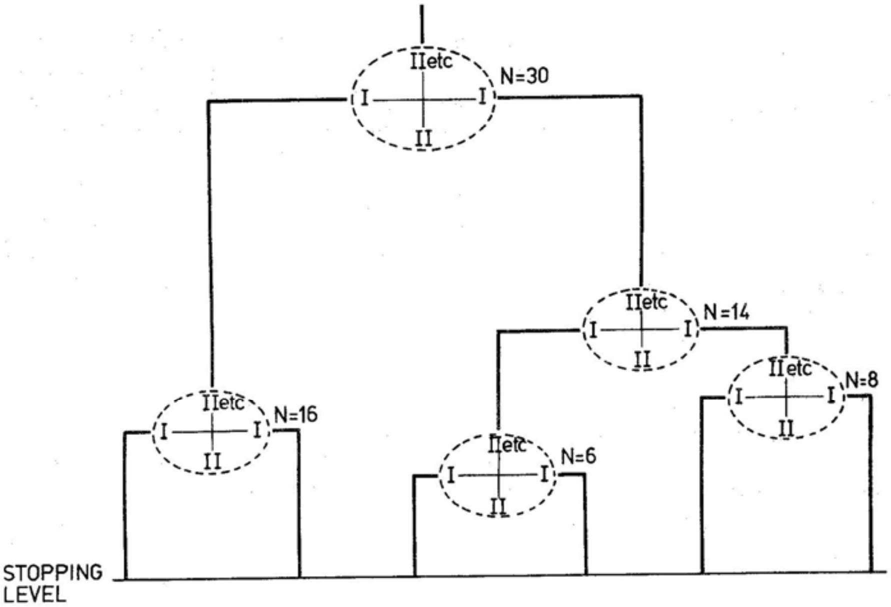

Fig.2. AXOR classification showing multi-level ordinations

DATA TYPE	NUMERICAL CONSTRAINT		EXAMPLES
	SPECIES	SITE	
UNBOUNDED	–	–	BIOMASS
PARTIALLY BOUNDED	+	–	QUALITATIVE, FREQUENCY
BOUNDED	+	+	PERCENT COVER

Fig.3. Floristic data types

those which structure in relation to all attributes of the matrix i. E. polythetic methods. We have found one such method, known domestically as AXOR (LAMBERT et al. 1973), particularly useful in studies of plant/environment relationships. AXOR is essentially a method of directed search based on a series of either Principal Components or Principal Co-ordinates which operate independently on each sub-population (fig.2). Its performance is consistently high in relation to other polythetic techniques and the multi-level ordinations obtained provide useful ancillary information for interpretation.

Since floristic and environmental patterns are complex phenomena,the particular facet of pattern revealed will depend to a large extent on the nature of the dataused for analysis. Not only will this represent a particular aspect of the situation but various interactions will also arise between particular numerical features of this data and the resemblance functions employed (WILLIAMS et al.1973). For floristic data,the type of pattern revealed will depend to a large extent on the nature of the floristic measurement adopted. Certain aspects of pattern may be expected to be more relevant to a primary analysis of plant/habitat relationships than others; it is these patterns and their corresponding floristic measures which are sought. Floristic measures may be divided into three groups (SMARTT et al.1974) : (a) unbounded measures,i. E. those data types with no numerical constraint either on the separate values for the individual species or on the overall totals for the individual sites, e. G. biomass ;(b)partially bounded measures,i. E. Data types which are constrained to a ceiling value for each species but which vary in overall site value according to the number of species at each site ,e. G. Frequency and qualitative data; and (c) bounded measures, i. E. Data types which are constrained to a ceiling value for each site irrespective of the number of species present, e. G. Percent cover (fig.3).

In terms of the classifications which they produce, on the one hand unbounded measures may be dominated by between-site differences in overall bulk of plant material present, whilst, on the other,partially bounded measures may by between-site differences in species richness. In either case differences in overall floristic composition between the sites may be completely obscured, particularly in analyses resulting from unbounded measures. In contrast, the primary feature of bounded measures is likely to be the extent to which single numerically well-represented species may dominate the analysis at the expense of a large number of less well-represented species which may be important indicators of environmental change. Thus the different numerical features of unbounded partially bounded and bounded floristic measures may be readily displayed in the classifications they produce. This is illustrated in fig.4 which shows the distribution along a transect of quadrats separated at the first division of an AXOR classification for each of six floristic measures. The biomass and square-root biomass classifications differentiate the old heath quadrats possessing very bulky plant material, whilst the percentage biomass and percentage cover classifications differentiate quadrats of the drier areas oa the basis of the relative abundance of a single species. In contrast, the frequency and qualitative classifications differentiate between the floristically rich and the floristically poor areas of the transect. In their extreme forms none of the features described may be particularly desirable, though most may be constrained by simple transformations of the data. Ecologically, the most useful measures will be those in which the extent of such undesirable features are limited or deliberately constrained.

Environmental data post rathe: different problems for analysis. Unlike the floristic data, the attributes of the matrix are not likely to be compatible in nature, nor are they likely to be numerically comparable in terms of their units of

	OLD ; CUT I OLD HEATH I HEATH. HEATH	BURNT HEATH	WET HEATH BOG
Quadrat No:	1 2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18	19 20 21 22 23 24
DATA TYPE			
BIOMASS	MN MI		

measurement. The features measured may range, for instance, from hydrogen ion concentration to estimates of grazing pressure,and *scales* of measurement between simple presence or absence, through ranked and unranked simple scales to continuous measures of quantity . Numerically heterogeneous data such as these, at minimum, require some form of standardisation prior to analysis, since attempts at structuring the raw data may simply reflect the pattern of those attributes with the largest numerical range.

However, perhaps the greatest difficulties arise in relation to the weighting of particular environmental features and subsequent effects of bias in the resulting classification. Certain forms of bias are unavoidable and simply reflect deliberate selection of some features for study to the exclusion of others. Since the number of environmental features which may affect plant growth are too numerous for complete evaluation, the consequences of deliberate selection must be accepted. The real dangers lie in the uncontrolled or unconscious weighting of certain features which may result from the number of attributes selected to represent them (CIPRA et al.1970; MUIR et al. 1970; AUSTIN et al.1972) ,lf,for example,certain types of measurements relating to a single feature are coded as a number of different attributes, then complete or partial necessary correlations between these attributes may give unfair weight to that feature. Weighting has two effects. The first is a direct effect on the course of the analysis which may arise as a consequence of the artificially increased importance of the feature involved; the second is a more subtle effect related to the effect of this weighting on the contribution of other features having various numerical relationships with the weighted feature. The latter point is illustrated in fig.5 where the percentage contribution of two environmental attributes to the first axes of a series of normal Principal Component analyses of habitat data decrease in importance and eventually reverse their relative positions in response to successive weightings of a third attribute.

Thus it may be noted that the initial selection of features for study and their subsequent coding as atrributes require great care,that the raw data require some form of standardisation, and that it may be desirable with very mixed forms of measurement to employ scales of approximately equivalent range.

In the light of the problems involved in the classification of floristic and environmental data, a decision is required as to whether correlations are to be sought between classifications of both components or between a classification produced by one of the components and the individual attributes of the other. For the latter, either site/plant or site/habitat classifications may be used as the reference system, and single species examined against the results of the habitat analysis, or vice versa. However, it is unrealistic to assume that variation in vegetation can be accounted for by variation in single environmental variables, or conversely that all variation in the environment can be fully represented by the behaviour of single species. It would seem more desirable therefore for a primary analysis to seek plant/environment relationships in terms of complexes of both species and environmental factors (AUSTIN 1968). An examination of correlations between parallel classifications of the sites in terms if their floristic and environment attributes separately provides a means by which the coincidence of such complexes may be examined (SMARTT et al.1976).

Methods for the correlation of separate plant and habitat hierarchical classifications either give general indications of their overall similarity in terms of a single coefficient, or provide a series of coefficients for each pair of groups, in turn. The former may compare classifications either in terms of their pathways of division, or in terms of their overall similarity in group composition at a particular level. (SMARTT et al.1974). Those which compare the pathway of analysis

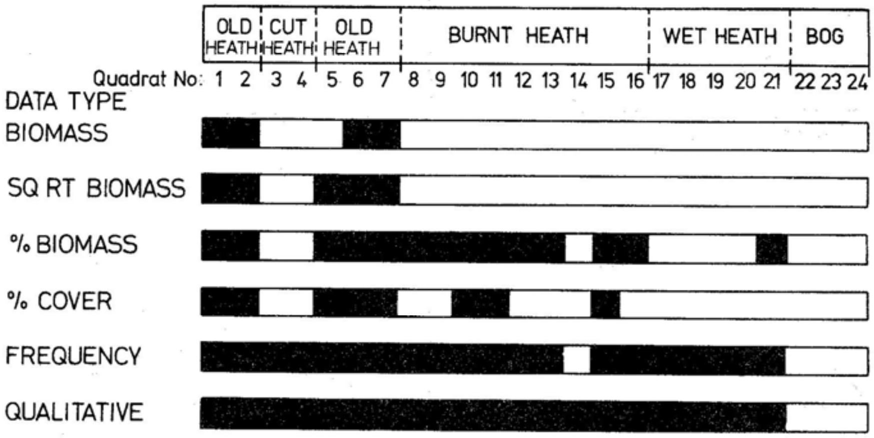

Fig.4. Distribution of quadrats at the two group level for AXOR classifications of different floristic data types

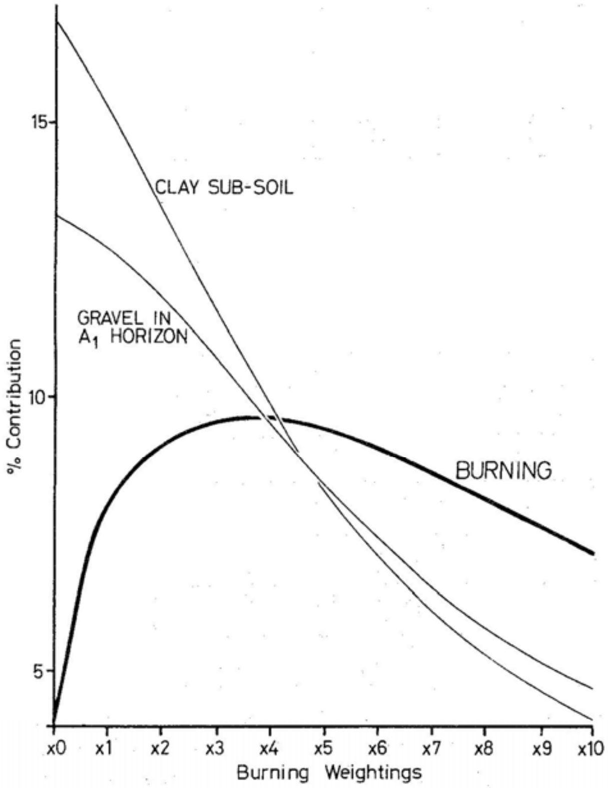

Fig.5. Percentage contributions of two environmental attributes to a series of Principal Component analyses with increasing weightings of a third attribute. The percentage contributions for the burning factor with weightings of x2-x10 are given as values for a single attribute.

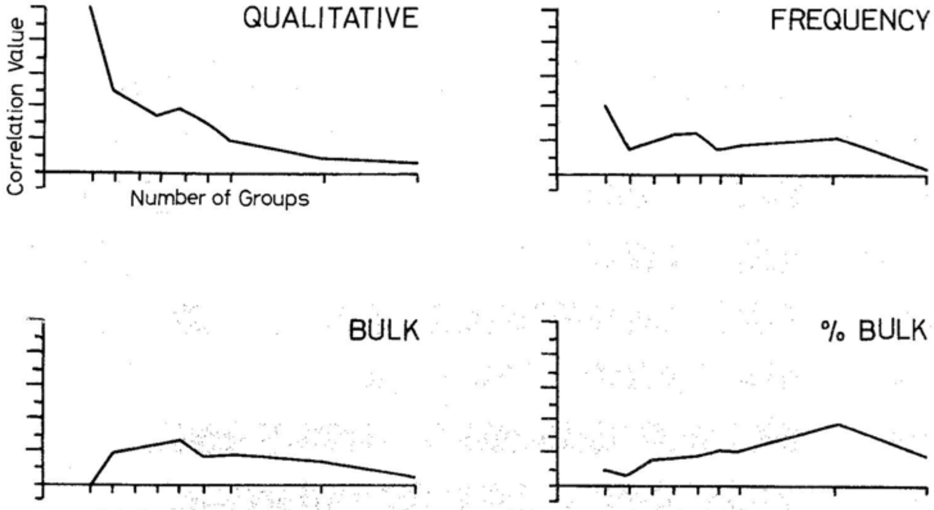

Fig.6. Correlation values at successive hierarchical group levels for each of four different floristic data type classifications against a habitat classification.

A.

VEGETATION GROUPS	r	HABITAT GROUPS
I	0.87	A
II	0.74	B
III	0.45	D
IV	0.36	E
V	0.35	E

B.

HABITAT GROUPS	r	VEGETATION GROUPS
A	0.87★	I
B	0.74★	II
C	0.41	II
D	0.45★	III
E	0.36★	IV

Fig.7. Group by group correlation of vegetation and habitat classifications at the five-group level.A gives the highest correlation (r) for each vegetation group with any of the habitat groups.B gives the highest correlation (r) for each habitat group with any of the vegetation groups.

x indicates cases where the best vegetation/habitat group correlation is also the best habitat/vegetation group correlation have serious limitations in the present context. Similar groupings may arise via diverse hierarchical routes,and there is no a priori reason in this instance, in view of the diverse nature of the matrices involved, why the two classifications should be similar in this respect. Overall group comparison methods may be useful under certain conditions, especially if a large number of classifications are to be compared at a particular group level, or if some general indication of areas of divergence and convergence in the two are required (fig.6). However, such techniques can only indicate overall similarity between sets of groups, and pairs with particularly high or low correlations cannot be pinpointed.

Group-by-group correlation techniques do not suffer this limitation and consequently enable specific floristic group/habitat group relationships to be identified (ORLOCI 1975; SMARTT et al.1976). The mechanism of operation of such methods is quite simple; each floristic group is correlated separately with each habitat group in turn and the highest correlation for each floristic group with any of the habitat groups retained. Conversely, the highest correlations for each habitat group with any of the floristic groups may be noted (fig.7). These values not only provide an indication of the extent of correlation across the separate groups, but also indicate those groups of sites where particularly high correlations between vegetation and habitat exist. An examination of the floristic and habitat features characterising these sites can then lead directly to hypotheses concerning plant/ environment relationships (fig.8a and 8b). In addition, floristic groups showing poor correlation with habitat groups may be examined and hypotheses generated as to the possible nature of environmental features which may be important for these groups but overlooked in the selection procedure.

In essence, the general approach put forward in this contribution operates via separate classifications of spatially defined sites in terms of their floristic and environmental features. Although the two components are structured independently, they are linked by the fact that the individual elements of both components are considered as attributes of the same set of sites. This link forms the basis from which further analyses may be carried out aimed at extracting correlations between the two classifications in terms of their group composition. The approach has several advantages. Firstly, when the two components are separated for analysis, the specific numerical features of each type of data may be considered in their own right and any appropriate adjustments made. Secondly, such an approach provides a basis for detailed comparisons which may be made in an objective manner without necessary recourse to simple visual correlations. Thirdly, if a classificatory method such as the one recommended is employed, the convenience of classification is combined with information obtained from multi-level ordinations, so that possible gradients between the groups, as well as the groupings themselves are available for interpretation.

Nevertheless,a great deal of work is still required in relation to the properties of and the means of handling both floristic and environmental data,both in their own right and in relation to the problems of non-linearity. Furthermore, it may be noted that since classificatory groupings form a focal point of the approach described, it would seem desirable to maximise the homogeneity of the groups themselves. The hierarchical classifications recommended do not deliberately seek this form of maximisation since the rote of formation of groups is all important. Their strenght lies in the ease with which the number of groups for study may be decided and it might in fact be recommended that, once this level has been set, an interation across the groupings should be carried out to maximise the internal homogeneity of the groups.

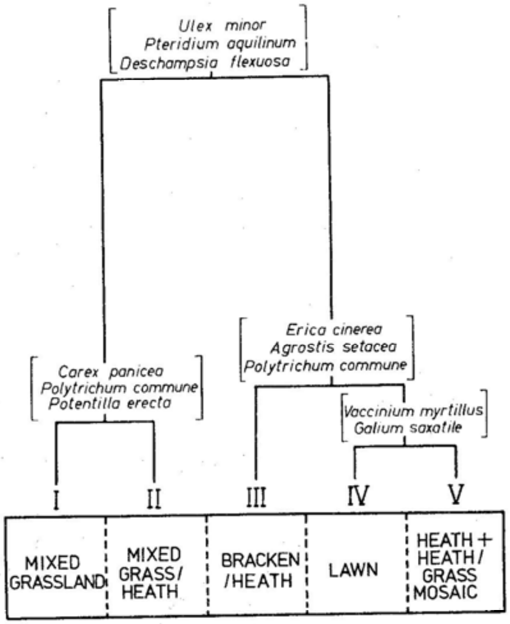

Fig.8a.Truncated vegetation classification of sites (AXOR)displaying species with high percentage contributions to each of the multi-level ordinations.Vegetation groups I-V correspond to those given in Table I A.

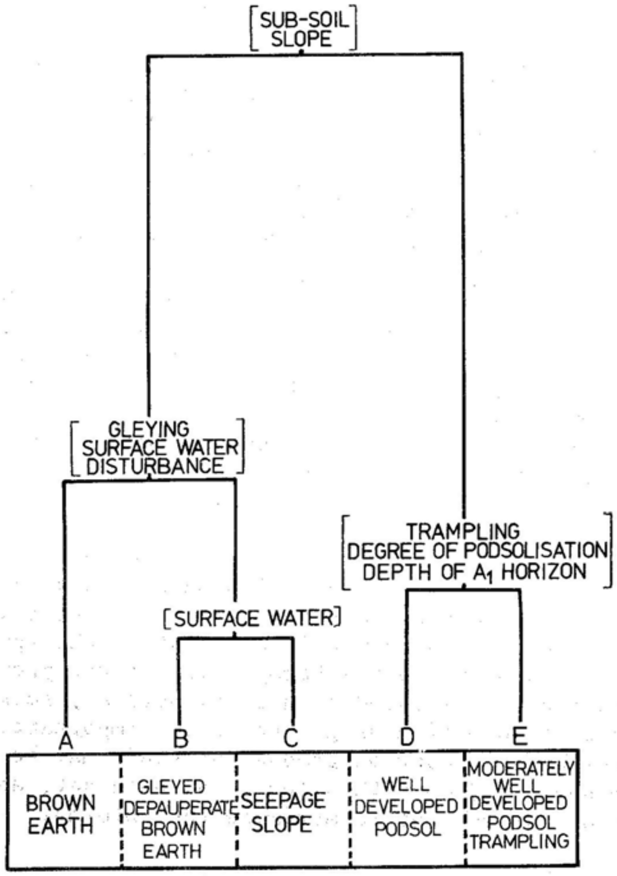

Fig.8b.Truncated habitat classification of sites (AXOR) displaying environmental attributes with high percentage contributions to each of the multi-level ordinations.Habitat groups A-E correspond to those given in Table 1 B.

In conclusion, it may be noted that although this contribution has been largely theoretical in nature,the framework outlined and the methods suggested have been used in a number of genuine ecological situations. The results have been encouraging and suggest that this approach to plant/habitat relationships is worth pursuing further, although it is clear that a number of difficulties still remain to be resolved.

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XVII. SOME OBJECTIVE LAWS A GAS EXCHANGE AND PRODUCTIVITY OF PHYTOCOENOSES

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Experiments carried out with different vegetable crops under controlled conditions of hermetic phytotrons with continuous registration of CO_2 and 0 alterations enabled us to determine the main rules of gas exchange and productivity of plants by varying environmental factors.

On the strength of intensity alterations of plants photosynthesis and respiration in ontogenesis one can calculate net photosynthesis and compare the value with the productivities of seedings (table 1). The study of assimilated CO_2 utilization for the building of biomass (coefficient of photosynthesis effectiveness – C eff) is of great interest, as it denotes integraL characterization of seedings activities depending on the properties of the whole of the optical-biological system of coenoses,namely photosynthesis and respiration intensities, the value and dynamics of leaf area development, radiation regimes of coenoses and other indices.

Table 1

Gas exchange and yield of plants under different radiation regimes

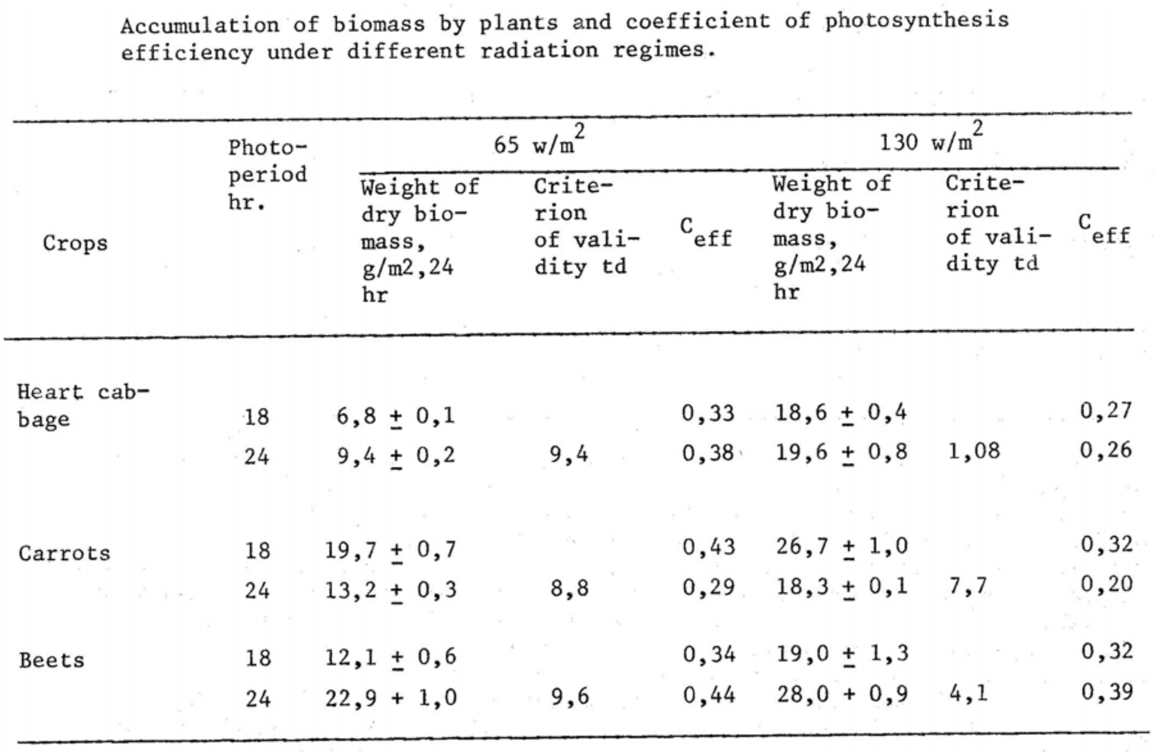
Crops	Irradiation Kcal/m2 in 24 hrs	Gas exchange in vegetative period ' gC0 2 of seedings		Net photosynthesis gCO_2/m_2 from 1m2 of seeding in vegetative period	Weights of dry biomass in vegetative period g/m2	Coefficient of photosynthesis efficiency C_{eff}
		consumed in light period	released in dark period			
Heart cabbage	1032	2322	477	1845	615	0,33
	2064	6993	834	6159	1677	0,27
Carrots	1032	5828	1724	4104	1773	0,43
	2064	10020	2545	7475	2405	0,32
Table	1032	3643	441	3202	1093	0,34
beets	2064	6213	819	5394	1712	0,32

The study of the efficiency coefficient of vegetable crop seedings carried out in phytotron showed that Ceff value was found within the bounds of 0.27 - 0.43 (table1), which is considerably lower than the theoretically possible value of the coeffecient (0.64). If corrections on released CO2 during the dark respiration are introduced in rated value of Ceff and the possibility that metabolic products are not related to the substances ef of carbohydrate type is taken into consideration then ceff value is not likely to exceed 0,5. Deviations of C_{eff} values from rated ones in our experiments are possibly attributed to different losses of carbon by plants. It seems likely that essential losses of organic matters are attributed to root excretions in the process of exosmosis and to losses of gelic substances by roots (HOLODNIY 1949; GUNAR et al.1956, 1959; UNTILOVA 1960; SAMTSEVICH 1956; GRODZINSKIY 1966; Mc DOUGALL 1968; ROVIRA 1969; FLOYD, OHLROGGE 1970; VLASYUK et al.1970; YURIN 1971; KOVAC 1971 and others), and also to gaseous output of carbon (SANADZE 1956, 1964; MISHUSTIN, NAUMOVA 1962; GRODZINSKIY 1966; NOVITSKAYA 1966, 1969; DADIKIN and al. 1970; ROSCHINA 1971,1974) . There are very few data on quantitative determinations of plant excretions, but based on them one can assume significant losses of carbon by plants and essential differences of C_{eff} values from theoretical ones.

Coefficient of photosynthesis efficiency is stipulated by growth conditions to a considerable extent. Our experiments showed that Ceff Increase in irradiation power gives the increase in CO2 absorption and in biomass accumulation but not in a direct ratio, that is CO_2 absorption increases to a greater extent than the organic matter for all of the studied crops (table 2). In this connection the value of Ceff is higher in seedings growing under lower light stream powers. On the strength of literary data it seems likely that as the light stream power increases the organic matter excretion to the environment by plants increases (SANADZE 1959,1964; KRAMER,KOZLOVSKIY, 1963; BURLAKOVA 1970; MAXIMOV , PIMENOVA 1971), this is possibly the cause of reduction of the coefficient of photosynthesis efficiency?

The efficiency coefficient depends on photoperiod under which the plants are grown. Results obtained in our experiments with 18-and 24-light day (table 2) pointed out that under favourable conditions for the biomass accumulation of given crop C_{eff} was characterized by higher indices.

Table 2



Accumulation of biomass by plants and coefficient of photosynthesis efficiency under different radiation regimes.

Crops	Photo-period hr.	65 w/m^2			130 w/m^2		
		Weight of dry bio-mass, g/m2,24 hr	Crite-rion of vali-dity td	C_{eff}	Weight of dry bio-mass, g/m2,24 hr	Crite-rion of vali-dity td	C_{eff}
Heart cab-bage	18	6,8 ± 0,1		0,33	18,6 ± 0,4		0,27
	24	9,4 ± 0,2	9,4	0,38	19,6 ± 0,8	1,08	0,26
Carrots	18	19,7 ± 0,7		0,43	26,7 ± 1,0		0,32
	24	13,2 ± 0,3	8,8	0,29	18,3 ± 0,1	7,7	0,20
Beets	18	12,1 ± 0,6		0,34	19,0 ± 1,3		0,32
	24	22,9 + 1,0	9,6	0,44	28,0 + 0,9	4,1	0,39

Variations of the coefficient of photosynthesis efficiency under different photoperiods possibly depend on the ratio of products formed during photosynthesis. The NORRISES and KALVIN (L. NORRIS,R. NORRIS,CALVIN 1955), NOVITSKIY (1962) ,MOKRONOSOV and LOGVINA (1962) demonstrated that favourable photoperiod contributed to carbohydrates formation. Under unfavourable length of the day synthesis of organic acids and amino acids increase. It is possible that this was the cause of reduction of photosynthesis efficiency coefficient.

The reduction of coefficient of photosynthesis efficiency was also observed in experiments with radishes,where different conditions for photosynthetic and respiratory activities of seedings and biomass accumulation were created by varying the amounts of CO_2 in the dark period. It was established that as the activity of unfavourable factor increased C_{eff} decreased on an average from 0,67 to 0,36 during vegetative season.

Reductions of efficiency coefficient under unfavourable conditions can be explained by the increase of excretion of metabolic products into the environment (KATZNELSON, ROUATT, RAYHE, 1954; ROVIRA 1956,1959,1969; BELIKOV ,KRILLOVA 1958; BORNER,1960; KIRILLOVA 1961,1964; GRINEVA 1963; GRODZINSKIY 1966). Such a rule was also confirmed by our experiments. When growing radishes under favourable conditions (CO_2 = 0,10 - 0,15%) the amount of unaccounted carbon, calculated on the strength of elementary analysis, came to 9% , but as growing conditions changed for the worse the carbon losses increased to 21% , it is possible this was the cause of reduction of the coefficient of photosynthesis efficiency (table 3).

Table 3

Unaccounted amounts of CO_2 in seedings of radishes "Pink-red-with white tip" (the length of growing season-23 days, irradiation-130 w/m2 , light period -18 hours)

CO_2 concentrations in dark period %	Weights of dry biomass g/m2	Amounts of CO_2		Integral net-photosynthesis (gCO_2/ m2	Amounts of carbon in absorbed CO_2	Unaccounted amounts of carbon	
		%	g/m2			g/m2	%
0,10 - 0,15	651,21	37,16	242,04	976,44	266,28	24,24	9,10
0,40 - 0,45	540,56	38,05	205,68	954,88	260,42	54,74	21,02

The efficiency coefficient changes during vegetative period. According to the data , obtained in the experiments with radishes, the degree of CO_2 utilisation for biomass formation increases with the age of plants. The changes of C_{eff} in ontogenesis can be explained by alterations of metabolic trends during plants life activity. In the course of these alterations synthesis of nitrous substances predominates in new age with subsequent rearrangements to primary formation of carbohydrates .One can suppose that C_{eff} alteration is connected with the uneven losses of organic matters in ontogenesis during the life of plants.

According to our investigations per cent of unaccounted amounts of carbon depends on the length of vegetative period, namely for the crops with a short vegetation 9-21% were not accounted and for the crops with the length of vegetive period of 90 days this index came to 57-64% (table 4).

Table 4

Unaccounted amounts of biomass in seedings of different crops (irradiation 130 w/m2)

Crops	Length of vegetative period days	Weight of dry biomass g/m2	Amounts of carbon in biomass	CO_2 absorbed in vegetative period, g/m2		Unaccounted amounts of carbon %	Coefficients of photosynthesis effieiency
				experimental	calculated		
Radishes Pink-red	23	651	242	976	887	9,10	0,67
Radishes Dungan	45	1693	643	2720	2359	13,24	0,62
Field kale	45	616	263	1217	964	20,78	0,51
Carrots	90	2405	983	7475	608	61,74	0,32
Heart cabbage	90	1677	603	6159	2212	64,08	0,27

It is possible the part of excretion in respect to total weight of plant is larger for living plants with long vegetative period than for plants with short vegetative period. The latter can be stipulated by the size and duration of function of root systems, which excrete to environments larger amounts of different matters for longer term both in the process of exosmosis and as a result of the formation of gel-like covers enveloped the roots.

Analysis of data on biomass accumulation and absorption of carbon dioxide leads us to the conclusion that in certain cases favourable conditions for the development of plants assimilation apparatus, intensive photosynthetic activity, ratio of photosynthetic to respiratory gas exchange do not ensure high productivity of plants. When determining the growing conditions it is necessary to ensure not only the intensive photosynthetic activity of plants seedings, but also to create conditions for minimum losses of organic matters by plants.

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XVIII. LABORATORY MATERIAL AND MATERIALS

A) Ultraaonic Debitmeters

- The Societe Auriema-France could like to bring to your attention the pOssibility 'of measuring pressures,temperatures,viscosity and density of liquids using a Clampitron ultrasonic debitmeter series 240 and 241.

InformatiOn from Auriema-France-BP 46 14 8 Bd Alsace Lorraine-94170 Le Perreux; 6r Kay Ray Inc. Industrial Process Control. Equipment, 516 West Campus Drive, Arlington Heights, Illinois 60004' , USA.

b) A New Heraeus incubator with automatic CO_2 control

The Societe Heraeus-France with to announce a new incubator for cell cultures model B 5060 EK/CO2 ,capacity 212 litres, with temperature, humidity and CO2 regulation; and the possibility of direct pH regulation of the cell culture.

For further information write to :

Heraeus-France-Zone industrielle BP•18, 91401-Orsay-France

c) Special Filma for Covering Glasshouses

La Societe la Cellophane-Film divisionir wish to announce that in addition to the films Al 3F and Al 4F which have been in use for several years a new film, available July 1977 , Celloflex EVA 3)which has a durability of 3 years.

It is opaque to far infra-red emission by the earth preventing the loss of heat and also avoiding temperature inversions. It conserves during several months high light transmission. Condensation is formed in a thin film avoiding the formation of droplets.

Test experiments at INRA-SEI Alenya (France) on lettuces, tomatoes, melons and strawberries have shown earlier yields under celloflex than with PVC or polyethylene.

Persons requireringfurther information should write to :

Societe la Cellophane, Division films,
Usine de Bezons, BP 18
95871-Bezons (France).

d) Harry Sharp and Son

This company (worldwide suppliers to the Horticulture, Greenhouse, Nursery and Forestry Industries), send us the following letter :

We have worked in areas of the Mid-East and with various agencies throughout the world, including the United Nations F A 0. In addition to actually supplying materials for greenhouse construction and the environmental controls,we also have available, heating and air conditioning equipment as well as quite a variety of equipment and supplies.

We have worked extensively with all phases of plant growth in controlled environments and it is through this interest that we would like to introduce our company.

We recognize the need for future production under cover and even though we do distribute equipment, we are always extremely interested in the exchange of ideas and are always seeking information. Last summer, we had people in India, the Mid East and Europe looking at various types of equipment and structures as well as plant growth in the structures.

If you are, or if you know of the anyone who is interested in what we have to offer, please contact us at following address:

Harry Sharp and Son-420 8th Avenue North Seattle Washington 98109-USA

XIX. CLIMATE LABORATORY NEWSLETTER N°8 April 1977

Here we reproduce summary of this New Zealand review :

a) Controlled environment room use

Room use for the 12 months period : 1 may 1976 to 1 may 1977 was :

DSIR	Plant Diseases Div.Auckland	24	Room weeks
	Soil Bureau Taitu	20	"
	Crop Research Div.Palm.North	21	"
	Grasslands Div.Palm.North	97	"
	Total	194	"
Universities	Botany Auckland	48	"
	Horticulture,Massey	21	"
	Agronomy Massey	209	"
	Total	278	"
MAF	Levin HRC	24	"
Forest Research Institute			
	Physiology Rotorua	135	"
	Pathology Rotorua	42	"
	Total	177	"

The total occupancy of the Laboratory was 89% of the maximum.

b) New Facilities and equipment

The Plant Physiology Division is currently constructing six 10 x 7 m frame houses, Three will have dirt floors that can be cultivated and will be covered with bird netting. The other three will have concrete floors and will either be permanently covered with shade cloth or have demountable shade screens which can be used to give protection to newly potted or transplanted plant material. These three will be used immediately to accommodate the large numbers of pine and eucalyptus species that are used in the FRI frosting programmes.

The frames are located next to the glasshouse area at the edge of the field plots. Construction of some of the shade houses will be complete by the end of May.

The Biological Service Group has recently purchased a nuew Lambda Instruments Portable Leaf Area meter with a moving belt assembly. The instrument can either be used directly in the controlled environment rooms to measure the area of intact leaves on the plant or for areaassessments on detached leaves at the lab, bench.
In this regard it will supplement the existing meter.

c)Air pollution research

The Climate Laboratory management have recently been approached regarding the possibility of carrying out air pollution studies in the controlled environment rooms. The studies have been proposed as a consequence of thermal (Westland coal) and geothermal (Broadlands) power station development and the possible damage of native and exotic forest areas by sulphur dioxide (and other) emissions.

d) Technical systems

LIGHTING. The controlled environment room lighting systems have now all been upgraded. All of the high-pressure multivapour lamps are fitted with "Duraglow" reflectors and the low intensity daylength extension (photoperiod) lamps are installed in all rooms.

NUTRIENT SYSTEMS. A mineral nutrient solution injection system has been designed and built and is now under test. It will make use of the current controlled environment room plant watering system and will allow special nutrients (e. G. Low nitrogen vs. high nitrogen content) to be applied to individual trolleys within the room. At present, the nutrient system is organised to supply all trolleys in a room with the same solution. Special nutrients have had to be supplied to individual trolleys or plants by hand.

The nutrient distribution heads are also under re-design and test. The new design allows the use of more readily available components and is easier to assemble.

FROSTING ROOM3. The new frosting room refrigeration systems have now been in operation for 6 months and are operating effectively. Eight new soil temperature control trays have been constructed bringing the total to 20. This allows more rapid changeover of plants between frosting treatments as individual plants now do not have to be transferred between trolleys.

The frosting room data logging equipment has been completely overhauled and is functioning adequately.

e) Controlled environment cabinet workshop

The plant Physiology Division is to hold a workshop on 8-9 June 1977 to instruct technical personnel from around the country on the operation and maintenance of reach-in controlled environment cabinets. The two day workshop will involve 30 min talks on each of the cabinet systems and will be followed by 1 hr working group sessions.

Topics covered will include air conditioning (refrigeration and heating systems, humidifying and dehumidifying systems), lighting technology and the operation of electronic control systems. Instruction on fault diagnosis will be included.

f) Continuing projects

Flowering of Chinese gosseberry (Kiwi Fruit)
Ethrel induced ripening in tomatoes

g) New projects

The initiation of primordia in apical meristems of radiata pine. Expt 140. G. B. SWEET.

Effects of Handling on plant growth. Expt 149 M. F. BEARD SELL

Duration of drought and its effects on final leaf area and grain yield in maize. Expt 151 ,P. W. GANDAR .

Production of high-health ornamentals. III. Carnations,Chrysanthemums, daphne and rose. Expt 156. D. COHEN and K. S. MILBE.

Effect of temperature on final seed yield and oil content of safflower. Expt 158. L. GREEN and C. R. SLACK.

Competitive interaction of C_3 and C_4 Grasses as determined by temperature regime and timing of Defoliation Expt. 159. W. HARRIS and B. J. FORDE.

A study of the interrelationship of soil,seed and direct drilling machinery. Expt 161 M. A. CHOUDARY and C. J . BAKER .

Infection studies of *Mycosphaerella nubilosa* on *Eucalyptus Delegatensis* and *E. Regnans.* Expt 162. G. A. NATHAN and J. B. CORBIN.

Suiphatase activity and the supply of organics for plant growth. Expt 167. T. W. SPEIR and R. LEE.

Effect of repeated frosts of the same level of severity on radiata pine seedlings. Expt 163. L. M. GREEN.

Effect of increasing severe successive frosts on radiata pine seedlings. Expt 164. L. M. GREEN.

Effect of temperature and photoperiod preconditioning on frost tolerance. Expt 165. D. G. HOLDEN and D. A. ROOK.

Effect of water stress on frost tolerance in radiata pine. Expt 166. D. G. HOLDEN and D. A. ROOK.

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XX. NEW PERIODICAL

Irrigation Science

Edited by Springer International Verlag. Pays Bas

A new international journal starting in 1977[1] which publishes original contributions and short reports on the results of irrigation research, relevant from plant soil and atmospheric sciences as well as the analysis of field experimentation. Particular interests are : Physical and chemical aspects of water status and movement in the plant-soil-atmosphere system. Physiology of plant growth and yield response to water status. Plant-soil-atmosphere and water management in irrigation practice.

Measurement, modification and control of crop water requirements. Salinity and alkalinity control by soil and water management. Ecological aspects of irrigated agriculture.1977 : D. M. 148 plus postage and handling.

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XXI. ASSIMILATE TRANSPORT IN PLANTS

by A. L. Kursanov (in Russian)

This book edited by "Nauka" from Moscow 1976, 647 pages, 156 figures and 67 pages of references, including all the aspects of transport and distribution of the products of photosynthesis in plants. The following are covered in the many chapters: the formation of exportable assimulates in the chloroplasts, their passage in the cytoplasm, transport in the foliar parenchyme, the accumulation of photosynthetic products close to the terminations of the phloem, transport in the phloem over long distances, the circulation of assimulates in the complete plant, and finally their accumulation in the reserve organs. Each problem is studied from a number of aspects: physiology, biochemistry and cytology ; and in addition a very comprehensive bibliography section is included. In the book attention is brought to the importance of the transport processes of assimulates for the coordination of all the functions of the entire plant : nutrition, growth , biosynthetic activity, accumulation of nutrients in the reserve organs (seeds,roots,tubers) which in general compose the most useful part for harvesting.

The paper is divided into three parts.

I. Assimilate transport in the leaf blade

- Chapter I. Assimilate translocation in photosynthetic cells
- Chapter II. Transport of assimulates in the leaf parenchyma

II. Phloem transport

- Chapter III. The ultrastructure of phloem
- Chapter IV. Biochemistry of phloem
- Chapter V. Physiology of phloem transport

III. Distribution of Assimulates in Plants

- Chapter VI. Interaction between donor and acceptor organs
- Chapter VII. Sucrose accumulation in storage tissues

General Conclusions

Intended for a large public of biologists this book is both useful practically and equally as a source of references. One can but regret that this magnificent work was written in Russian thereiy restricting its utilization in the west.

XXII. MODES OF REGULATION OF AIR CONDITIONING SYSTEMS

by A. A. Rimkevich and M. B. Khalameizer (In russian)

This book edited by Machinostroenie (Moscow) in 1977 (280 pages, 11 tables and 110 figures) analyses two fundamental aspects of the problem of regusting air conditioning systems : static and dynamic, the optimization of the mode of regulation of air conditioning systems. It comprises of the following chapters:

1) Basic principles of air conditioning systems
2) A thermodynamic model of air conditioning system
3) Technological scheme of air conditioning systems
4) Functional scheme of automatic regulation of air conditioning systems
5) Mathematical models of the dynamics of the essential elements of air conditioning systems.
6) Analogous models of the dynamics of air conditioning systems.
7) The general basis of the regulation of air conditioning systems.
8) Modern systems of regulation of air conditioning regimen.

This book is intended for engineers and specialist tesearch groups concerned with air conditioning systems and also students specializing in this subject

Editor : Machinostroienie-1st Basmanovsky per Vol.3
Moscow GSP 107 885. URSS.

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XXIII. LIVRES NOUVEAUX - LIST OT NEW BOOKS

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XXIV. ARTICLES SIGNALES - ARTICLES IN PRINT

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XXV. REUNIONS ET EXPOSITIONS ANNONCEES
COMING EVENTS, MEETINGS AND EXHIBITIONS

1977. August 1-5 -Kyoto-Japan

1FAC Symposium on Environmental systems planning,design and control
Inquiries : Prof. Sawaragi . Fac. Of Engineering Kyoto University
Kyoto 606-Japan

1977. August 16-20 . Cacak (Yugoslavia)

IIIrd Meeting of the Working Group on Plum Genetics and Plum Breeding (ISHS)
Inquiries : Dr. R. Bernard,Station d'Arboriculture Fruitiere de Bordeaux,
33140 Pont de la Maye,France.

1977. August 22-25 . Renesse (The Netherlands)
Symposium on clonal variation in apple and pear (ISHS)
Inquiries : Dr. H. J. Van OOSTEN, Research Station for Fruit growing.
Wilhelminadorp (post goes),the Netherlands.

1977. August 22-26. Alnarp (Suede)
ISHS International Symposium on more profitable use of energy in protected cultivation.
Inquiries : Secretary -Dept. Of Floriculture and ornamental Horticulture-Agricultural University of Sweden 5.230-53 Alnarp,Suede.

1977. August 23-25. Wilhelminadorp (The Netherlands)
ISHS Symposium on Intraclonal selection in apple and pear
Inquiries : Dr. H. J.OOSTEN,Research Station for Fruit Growing.
Wilhelminadorp, The Netherlands.

1977. August 28- September 25,Erfurt (RDA)
International Horticultural Exhibition
Inquiries : Reiseburs,B P 77, Alexanderplatz DDR 1026 Berlin,RDA.

1977. August 29-September 2 (Japan)
8th Int. Consr. Int. Union of Biological Science
Inquiries: Dr. H. Terayama, Zoological Inst. Fac. of Sci. Univ. Of
Tokyo, Hongo Bunkyo ku Tokyo 113,Japan.

1977. September (Yugoslavia)
ISHS Symposium on Growth regulators in fruit production
Inquiries: Dr. Luckwill, Long Ashton Research Station Bristol BS 18 9 AF,U. K.

1977. Septembre,Moscou (URSS)
Symposium: Cinetisue et thermodynamique des processus intermadiaires dans les systestes bioloeques
Renseignements: Commission d'Etude Ac. Sc. URSS ,Centre de Recherche de Biologie,
Pushchino, Region de Moscou 142292, URSS.

1977. September (The Netherlands)
Symposium on Vesetable irrigation
Inquiries : Prof. H. D. Hartmann, Inst. F. Gemusebau,
6222 Geisenheim/Rh, FRG.

1977. September 1-14,Bet Dagan (Israel)
ISHS Symposium Water supply and Irrigation
Inquiries: Mr. SCHALLINGER, The Volcani Center,POB 6 Bet Dagan,Israel.

1977. September 4-7 Pavia (Italie)
XIII International Conference of Society for Chronobiology
Inquiries: Secretary Office, ISC XIII Conference, P 0 Box 1071 20100.
Milano, Italia.

1977. September 4-9 Reading (U K)
4th International Congress on Photosynthesis
Inquiries: Prof. D. O. HALL,University of London,King's College,68
Half Moon Lane London SE 24,U. K.

1977. September 4-10 Tokyo (Japan)
26th International Congress of pure and applied Chemistry
Inquiries: 26th Congress of IUPAC, P 0 Box 56, Kanda Post Office,
Tokyo 101-9I,Japan.

1977. September 5-9 Budapest (Hungary)
5th Symposium on Horticultural Economics
Inquiries: Ir. W. G. De MANN,Agric. Econ. Institute,Conradkade
175, The Hague,Netherlands.

1977. September 7-9 Ghent (Belgium)
ISHS Symposium on in vitro culture for horticultural purposes
Inquiries: Prof. G. BOESMAN,Coupure Links 533 9000
Ghent,Belgium

1977. Septembre 9-12 Reims (France)
Festival du Dahlia en Champagne
Renseignements: Societe' d'Horticulture de Reims, 51100 Reims,France

1977. September 12-16 Dublin (Ireland)
ISHS Symposium on the propagation and raising of nursery stock
Inquiries : J. C. KELLY, Kinsealy Research Centre,Malahide Road,Dublin,Ireland

1977. September 12-16 Leipzig (GDR)
Symposium on control mechanism in bio and ecosystems
Inquiries : Wissenschaftlich-Technische Gesellschaftf. Messund Automatisierungs-
technik ,1086 Berlin GDR

1977. September 12-16 Norwich (UK)
First European Ecological Symposium
Inquiries: Gesellschaft fur Okologie,2 Untere KarApule 3400 Gottingen Germany F. R.

1977. Septembre 12-30 Paris (France)
Microbiologie du sol et des eaux, cycle de formation continue
Renseignemnts: ADEPRINA,16 rue Claude Bernard,75231 Paris Cedex 05,France

1977. Septembre 14-17 Nice (France)
3e congres mondial Interflora et Florexpo
Renseignements:Fed6ration Nationale des Fleuristes de France
33 rue de Pont Neuf,75001 Paris,France

1977. September 17-25. Valencia (Spain)
Iberflora 77
Inquiries: Iberflora Apartado 13,Valencia Spain.

1977. September 19-21 Poznan (Poland)
Working group on Growth regulators in fruit production (ISHS)
Inquiries: Dr. J. JONKERS Dept. Of Horticulture,Agricultural
University, P 0 Box 3,Wageningen 6140,The Netherlands

1977. September 19-22 Dublin (Ireland)
ISHS Symposium on production of protected crops in peat and other media
Inquiries: M. J. MAHER,Kinsealy Research Centre,Malahide Road,Dublin
5,Ireland

1977. September 21-23. Amsterdam (Netherlands)
8th ELCA Congress
Inquiries: ELCA -Thomas Jefferson Laan 467 ZH Netherlands

1977. September 27-30 Nottingham (UK)
Symposium on seed problems in Horticulture (ISHS-ISTA)
Inquiries: Dr. W. HEYDECKER,University of Nottingham,Dept. Of Agriculture and
Horticulture,Sutton Bonington,Loughborough LE12-5RD,England UK

1977. October 5-6 R F Germany
Annual Congress of the Association for Plastics in Agriculture (GKL)
Inquiries: G K L Geschaftsstelle KTBL D-6100,Darmstadt-Kranischstein,
Bartningstrasse 49,RF Germany

1977. October 5-7 Beltsville (USA)
International Symposium on Calcium Nutrition of Economic Crops
Inquiries: C. B. SHEAR,Beltsville Agricultural Research Center
Beltsville, Ma 20705 USA

1977. Octobre 8-9 Paris (France)
Grande Exposition d'Horticulture et des plus beaux produits du jardin
Renseignements:Societe Nationale d'Horticulture de France,84 rue de Grenelle
75007-Paris France

1977. October 14-23,Copenhagen (Denmark)
International Flower Fair and Horticultural-Technical Fair 1977 at the Bella Center
Inquiries: Danisk Association of Horticulture Producers Copenhagen Denmark

1977. Octobre 18 Versailles (France)
Reunion sur le theme Modelisation de l'Ecosysteme prairial
Renseignements: Ir. P. JACQUARD-CEPE Louis Emberger B P 5051-34033 Montpellier
Cedex France

1977. October 30-November 2 Birmingham UK
International Exhibition G L E E
Inquiries: GLEE Inter Garden Promotion Ltd,Columbia House 69 Aldwych London
WC 2 B4DY U K

1977. Novembre 22-24 Versailles (France)
Congres AFCET sur la modelisation et la maitrise des systemes techniques,economiques,sociaux
Renseignements: AFCET,156 bd Pereire 75017. Paris

1977. November 27-December 2nd Khartoum (Sudan)
5th African Symposium of Horticultural Crops (ISHS)
Theme : Horticultural research and development in the arid zones of Africa
Inquiries: Dr. A. T. HAFFEZ Dept. Of Horticulture,lJniversity of
Khartoum,Shambat The Sudan

1978. January Israel
ISHS Symposium on water supply under glass and plastics
Inquiries: Dr. K. M. SCHALLINGER Inst. Of Soils and
Water The Volcani Center. POB 6 Bet Dagan Israel

1978. January 8-15 Bet Dagan (Israel)
ISHS Symposium on water supply and irrigation
Inquiries: Dr. K. SCHALLINGER Organizing Committee
A R 0 Volcani Center PO Box 6 Bet Dagan Israel

1978. Fevrier 6-8 Quebec (Canada)
Congres National de Paysage du Canada avec exposition commerciale
Renseignements : Les Productions David Courtin a/s les Services GSC
Case Postale 91. Champlain Lassalle,Quebec Canada

1978. May 31-June 9 Paris (France)
10th International Congress on Mushroom Culture
Inquiries: Secretariat 10e Congres Champignons comestibles
INRA Bordeaux, 33140,Pont de la Maye,France

1978. April-May Avignon (France)
ISHS Working party on "Optimization of growth through control of the micro - climate"
Inquiries: Dr. J. DAMAGNEZ INRA Station de Bioclimatologie. Domaine de St Paul
Cantarel 84140-Montfavet France

1978. June. Sweden or Norway
Symposium on Landscaping of cut-off bogs Inquiries:Prof. Kuntze.
Ausseninst. Bodenkunde,Friedrich. Missler Str.46-48 2800 Bremen BRD

1978. June 12-16 Alnarp (Sweden)
Symposium on quality of vegetables (ISHS)
Inquiries: Dr. Torsten Nilsson,Department of Vegetable Crops Agricultural
College of Sweden S 230 53 Alnarp (Sweden)

1978. July 9-14 Edinburgh UK
Inaugural meeting of the Federation of European Societies of Plant Physiology
Inquiries: J. E. DALE ,Department of Botany,University of Edinburgh ,Kines
Buildings Edinburgh EH9 3JH UK

1978. July 24-28 Zurich (Switzerland)
4th int. Congress of Pesticide Chemistry
Inquiries: Secrgtariat PO Box 182 CH.4013, Basle,Switzerland

1978. August 15-23. Sydney (Australia)
20th International Horticultural Congress
Inquiries: Secretary of Congress, GPO Box 475,Sydney NSW 2001,Australia

1978. August 16-23 Munich Germ. Fed. Rep.
3rd International Congress on Plant•Pathology
Inquiries: Congress Plant Pathology, Biologische Bundesenstalt
Messeweg 11/12 D.3300 Braumschweig FR Germany

1978. August 21-30 Moscou (USSR)
14th International Congress of Genetics
Inquiries: Organizing Committee XIV-101G rue Fersman 11,Apt.4,
Moscow 117312,USSR

1978. Aout 21-Septembre 2 Gembloux Belgique
Cours de vacances: Statistique et informatique appliques
Renseignements: Prof. P. DAGNELIE,Facult6 des Sciences agronomiques
5800 Gembloux Belgique

1978. August 24-28 Japan
International Symposium on Potential Productivity in Protected cultivation
Inquiries: Dr. T. TAKAKURA Dept. Agric. Eng. University of Tokyo, Yayoi-cho,Bunkyo Ku,Tokyo 113,Japan

1978. September 3-9 Poznan (Poland)
8th International Biometeorological Congress
Inquiries: Dr. M. KLINOWSKA International Society of Biometeorology Dept of
Anatomy. University of Cambridge Downing Street Cambridge EB2 3DY
UK

1978. Septembre 4-8 Gembloux Belgique
Semaine d'etude internationale:Stattstique et informatique en Agronomie
Renseignements: Prof. P. DAGNELIE,Faculte des Sciences Agronomiques,
5800 Gembloux Belgique

1978. September 4-8 Wye College (UK)
Symposium on Labour and Labour management
Inquiries: J. A. H. NICHOLSON School of Rural Economics and Related
Studies Wye College Nr Ashfort Kent TN25 5 AH UK

1978. Octobre 18-29 Iberflora Valencia Espagne
Inquiries: Iberflora,Apartado 13,Valencia Espagne

1979. Brazil
Second South American Symposium on Vegetables
Inquiries: Secretariat ISHS Bezuidenhoutseweg 73 ,The Hague Netherlands

1979-1980. Los Banos Phillipines
Symposium on problems of vegetable research
Inquiries: Secretariat ISHS. Bezuidenhoutseweg 73 ,The Hague Netherland,

1979. Spring Skiemiewice (Poland)
Symposium on Growth regulators in floriculture
Inquiries: SkiezniewicePoland

1979. March or April Trichur (India)
ISHS Symposium on Cashew nuts
Inquiries: J. G. OHLER Tropical Institute;Mauritskade
63 Amsterdam -0-The Netherlands

1979. August. Aarslev (Denmark)
Production planning of Glasshouses floriculture (ISHS)
Ifiquiries: Dr. O. V. CHRISTENSEN,Research Institute for Glasshouse Crops
Kirstinebjergvej 10,DK-5792 Aarslev,Denmark

1979. Avril 28-Octobre 17. Prague (Tchecoslovaquie)
Exposition agricole

1979. 6 mois Bundesgartenschau BONN (FRG)

1980. Fed. Rep. Germany
Fifth ISHS Symposium on virus diseases of ornamental plants
Inquiries: Dr. R. Koening Inst. Fur Virusserologie
Messeweg 11/12 33 Baunschweig BRD

1980. Aarslev Denmark
Third ISHS Symposium on Flower bulbs
Inquiries: State exp. Station-Aarslev Denmark

1980. Avril Gand (Belgique)
Floralies gantoises

1980. 6 months. Exposition nationale horticole,BRle (Suisse)

1981. Avril Genes (Italie)
Euroflora

1982. 6 months Floriades des Pays-Bas

1982. Hambourg (FRG)
21st International Horticultural Congress
Inquiries: Prof. D. FRITZ,Institut fur Gemusebau 8050 Weihenstephan-Freising/008,
Germany, Fed. Rep.

1983. 6 months IGA à Hambourg (FRG)

1984. 6 months WIG, Vienne (Autriche)

1985. Avril. Floralies gantoises (Belgique)

Nous remercions à l'avance,tous ceux qui nous enverront des informations ou articles que nous reproduirons,si possible,dans les prochains numeros.

We thank, in advance, all those who will be sending us reports or news to print in coming issues.

R. JACQUES and N. De BILDERLING