Secretariat Phytotronique
Phytotron C.N.R.S.
91190 Gif-sur-Yvette
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PHYTOTRONIC NEWSLETTER N°15

Contents

News and Miscellaneous information:

I - EDITORIAL

In certain preceding issues we have taken up subjects which above all were of interest for horticultural or agricultural practice. The last issue was divided between: fundamental research and applied research.

In this issue and probably for the following three issues in 1977, we plan to publish a series of articles and papers presented at the Botanical Congress in 1975, revised and brought up to date by the authors, which are liable to interest our readers.

At first, we thought of compiling these articles in a separate volume (Phytotronic IIT) following up the proceedings of the three preceding meetings (London 1964, Tel Aviv 1970 and Warsaw 1974). Unfortunately, all our efforts to find subsidies for such an edition failed. Therefore, THE PHYTROTRONIC NEWSLE1TER will ensure the diffusion of these documents, without charge, which are certainly of interest.

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This 15th issue is the first one for 1977 and we hope to be able to maintain a regular publication in the future in spite of financial difficulties.

We thank all those readers who write to us encouraging us in our endeavor 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 frais de parution de 'Phytotronic Newsletter'" and making cheques in the name of:

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This issue comprises several chapters:

a) Meetings. Only two meetings are noted under this chapter heading; we regret not **to be** 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.

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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

II - STUDIES IN PLANT BIOLOGY

This book, edited by R. Jacques, Assistant Director of the Phytotron at Gif-sur-Yvette and referred to in our preceding issues, has now been published. It was handed to Professor Chouard by Professor H.J. Maresquelle during a cocktail reception on January 26, 1977 given at the University of Paris VII, in the presence of numerous subscribers and friends. This book takes up various aspects of plant biology to which Professor P. Chouard has contributed, either directly or indirectly, throughout his career.

This jubilee book commemorates the career of Professor Chouard: As Professor Maresquelle pointed out, the word "jubilee" (in dictionaries or encyclopedia) recalls an ancient Hebrew celebration: "a religious and domestic celebration observed at the end of fifty years of the exercise of a function", which is the case with the professorship of Dr. Chouard.

44 articles have been collected in this book and are listed as follows:

- Wellensiek S.J. - A genetical look on flower formation in Silene armeria L.
- Martin C. - La plante, ses parasites, son environnement.
- Went F.W. Le Phytotron comme trait d'union entre la conception et la realite d'une plante.
- De Bilderling N. et Lourtioux A. - Quinze annees de phytotronique.
- Hubac C. - La resistance a la secheresse de deux especes de Carex.
- Blondon F. - Interactions de la lumiere et de la temperature sur la floraison: les concepts d'induction primaire et d'induction secondaire.
- Jacques M. - Determinisme de la mise a fleurs de deux Chenopodiacees de jour long (Blitum caoitatum et Blitum virgatum) etudiees en Phytotron.
- Larrieu C. - Quelques reflexions ***sur*** le determinisme de l'etat vivace et de lietat bisannuel chez deux Scrofulaires: Scrofularia elate et Scrofularia vernalis.
- Tran Thanh Van M. - A propos de liorientation sur commando de in morphogenese experimentale. De la plante entiere A in cellule isolee que choisir?
- Miginiac E. et Sotta B. - Interactions de facteurs correlatifs ***et*** photoperiodiques dans la miss a fleurs d'une plants de jours longs, le Scrofularia arguta at d'une plante de jours courts, le ⌐Che n000-dium polyspermum.
- Jacques R. et Lecharny A. - Photomorphogenese du Chenopodium polyspermum L.
- Monard J.F. at al. - Periodieite journaliere du flux de seve et transport ascendant du potassium (Helianthus annuus L. et Lycopersicum racemigerum Lange).
- Brulfert et al. - Etude comparative de l'induction photoperiodique aux niveaux morphogenetique et metabolique.
- Morel C. - Rythmes circadiens: interactions entre voles metaboliques.
- Queiroz O. - Un modele pour les relations entre photoperiodiame, horloge biologique et regulation enzymatique.
- Cosson L. - Importance des facteurs climatiques et des stapes du developpement dans la productivite des alcalo!des tropaniques.
- Aghion J. - Essai de description d'un modele de structure photosynthetique.
- Kursanov A.L. et Paramonova N.V. - On the state of membranes in *mese*-phyll cells of Beta vulgaris in terms of assimilate traebpoft.
- Lechevallier D. et al. - Qualite spectrale de in lumiere et lipides plastidiaux du Ble et de in Spirodele.
- Moyse A. - Le metabolisms C_4.
- Pradet A. et Ferron C. - Metabolisme energetique au cours de la germination du Riz en anaxie.
- Huault C. et al. La phenylalanine emmoniac-lyase, structure, proprietes et regulation.

At the end of the volume, the names of 309 persons and 21 laboratories or organizations are given which participated financially in the publication. To this subscription list must be added:

MM. H. Flon, Ph. Gautier, D. Fontaine, M. Hanza, J.L. Hamel, C. Bulard et F. Prevot - Laboratoire de Botanique de Montpellier - Societe Hortiflora International - Ets. Ernest Turc Societe Nationale Elf Aquitaine - Societe Aurore - S.C.I.R.O. (Australie).

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Persons desiring to obtain this volume may do so by subscribing with a minimum amount of WO French Francs and may sent those to us with the endorsement:

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[III - I.S.H.S. SYMPOSIUM ON FLOWER FORMATION IN ORNA1.MNTALS

Pisa, Italy, September 27-30, 1976

We are only able to give a very brief summary of this three day meeting, connected with the Ornamental Plant Section of the International Society of Horticultural Sciences and held under the auspices of Professor Alpi of the Faculty of Agronomy at Pisa.

75 participants, some of them with their wives, attended from 13 countries.

Several papers were presented on panels (Poster Service), mainly those which discussed particular cases of some treatments which are new and appropriate to floral production of certain species.

September 28 : Lecture by Professor Wellensiek (the Netherlands), and September 29: Lecture by Professor R. Sachs (USA, David Ca.). Both these lectures complemented each other with the main subject being flowering. Wellensiek discussed hormones and genetics and Sachs, the capital role of maximal energy (sugars and ATP).

It is hoped that a colloquium - a round table for discussions - will soon take place with researchers working on the problems of flowering. This may allow new strategies, or working hypotheses, to emerge which could circumvent difficulties or find a way of tackling insoluble problems with which the majority of physiologists working on these problems have to face.

The excursions on September 30 were devoted to two truly remarkable visits of Italian ornamental flower industries, one on orchids, able to supply the entire Italian market, as well as other exotic plants; the other on the production of new breeds of carnations and the industrial manufacture of cuttings, with no virus, according to the French method of G. Morel, so successful in Antibes (France). The end of the day was used for two visits to decorated parks at Pescia, one done on the "Pinnochio" theme, the other being the magnificent park of the castel of Collcdo, the village adjoining Pescia, where the author of Pinnochio was born.

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Another I.S.H.S. symposium on Pear culture took place in Florence (Italy), October 3-5, 1976, under the auspices of Professor Scaramuzzi. Many participants took part in both these symposia.

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Persons who would like to receive summaries of these events should contact the Secretary of the I.S.H.S.: Bezuidenhoutseweg 73, The Hague, Holland.

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IV - INTERNATIONAL CONGRESS OF SOILLESS CULTURE: IWOSC - Las Palmas, Canary Islands

October 24 - November 1, 1976

a) Some details about IWOSC

IWOSC, an international working group on soilless culture, exists since 1955. It was created during the 14th International Congress of Horticulture in

Scheveningen, the Netherlands. It is a private non-profit organization, grouping about 150 members throughout the world, which seeks commercial and technical applications for culture without soil, or hydroponics. Of course, the majority of the members are found in desert areas or in regions having difficulties in supplying water for irrigation, for example many islands or volcanic archipelagos.

Every 3 to 4 years, an international congress is held, with the publication of the proceedings: 1955 Scheveningen; 1958 - Nice; 1963 - Perugia; 1968 - Florence; 1969 - Las Palmas, Canary Islands; 1973 - Sassari. Finally, this year the 7th Congress will take place again in Las Palmas, Canary Islands.

Between the Congresses, the secretariat which is currently being directed by Dr. A.A. Steiner, is in the Netherlands. It publishes a bibliography of work done on soilless culture. The first volume was published in 1957 (2.700 titles) and the second in 1966 (725 titles).

b) Organization of the Congress

The Congress this year, which was held in Las Palmas, comprised three conference sessions: 1 complete day and 2 half days for 41 meetings.

There were 85 participants at the Congress, 20 of whom were accompanied by their wives, for whom a tourist programme was organized. In total, 29 countries were represented, with the largos delegations coming from: Great Britain (9), Spain and the Canary Islands (8), the Netherlands and Italy (each 7), the Usa (6).

The working sessions were held in the amphitheater of the Hospital and Medical Study Center, with simultaneous translations in English and Spanish, the only two official languages.

c) Excursions and Visits

Three excursions to study and visit installations on Grand Canary Island made it possible to verify an enormous general development of culture under plastic.

It was noted that there was still much land divided into small holdings and particularly with glass greenhouses, relatively less numerous elsewhere, and above all with plastic shelters.

The most widespread type of shelter remains the annual covering of polyethylene. However, a "Canarian shelter" is more and more seen on large areas, which follow the twisting relief of the ground, with terraces. It is a very light construction, with wire netting supported by two posts of eucalyptus wood which is very inexpensive. This shelter has no aeration system, which in summer consists in simply spreading apart the plastic films or the netting at the places where they overlap. Winter heating is generally not necessary, given the latitude. Eventually, a small plastic tunnel, called "caterpillar", is placed in the interior of the shelter, only during the few weeks of winter cold, and particularly for delicate plants, so that they can get through the short cold period without mishap.

Essential cultures are centered on the production under cover (greenhouse or plastic) of tomatoes between January and June, and of cucumbers between September and January. Outdoors, banana production is most important. As a general rule, all this production is reserved for export, mainly to Europe. Of course, all in hydroponics because of the general lack of water in these volcanic islands.

During the visits, two areas under cultivations on Grand Canary Island and two others, in post-congress excursions, on Lanzarote Island, could be seen.

A longer visit was devoted to the International Center for Hydroponics: Numerous tests on hydroponic culture are done here, following several orientations: 1) Perfecting the substrata to be used. 2) Acclimatization and introduction of new forest and horticultural species, notably Avocado and Mango. 3) Study of problems of irrigation in lines, in circles and, in each case, with variations of water to use, in quality and in quantity. Indeed, one of the essential problems for all of the Islands, and above all in the case of Grand Canary Island, is the lack of water. As soon as the water level goes down, there is a mixture of sea water, and the water for the irrigation gets more and more salinity, for which it is necessary to know the tolerance limit.

d) Congress sessions

The working sessions *opened* with a historical account of hydroponics, authoritatively presented by the General Secretary of 'WS°, A.A. St6iner (the Netherlands). He pointed out the various stages of development of the problems brought to light by the work of various Congresses.

In order not to summarize the various meetings which will be published by the Society, a general idea of the subjects taken up will be given, mentioning those which most impressed us:

- The development of hydroponics was sketched by various countries: the Canary Islands, the USSR and among others Armenia, Abu Dhabi, Ireland and Iran.

- For the forcing of Witloff Chicory, recent tests at the Alkmaar Station (Netherlands) have practically resolved the various problems, with security.

- The Canadians presented domestic greenhouses comprising a complete hydroponic installation for the home production of Tomatoes, Cucumbers, Lettuce and flowers during the winter month-L.

- Both the Dutch and the English have thought of using hydroponics in offices, entrance halls and large halls for flower and greenery decoration.

- Professor **J.** Sholto Douglas (India) presented in an authoritative way his reflections and analyses about the economic possibilities for the present and prospective use in the future of soilless culture.

- Studies about the substrata to use were numerous but very localized, according to mostly very local economic materials: rock, plastic, film rock wool, vermiculite, etc.

From a theoretical point of view it was noted that:

- The composition of the nutritive solution varies according to the users and the concentrations can be greatly increased without either being harmful for productivity or bringing any kind of noxious matter to the culture.

- Antitranspirents can be used without any difficulty and will economize water.

- Exchanging resins of ions make it possible to improve pH control, possible precipitations and ion captures by the plant in its surrounding environment.

- The rhizosphere, as well as the development of microorganisms are very variable and should be better studied.

- A very interesting remark was made about temperature and a thermic profile of the root environment in an inert substratum. By means of computers, some Belgian researchers to-0k up this problem which is of some importance for yields; the work has unfortunately been done in a greenhouse without air conditioning.

- A Dutch lecturer demonstrated an interesting possibility for studying the relationship between the host body and insects by means of hydroponics. He particularly demonstrated the possibility of making questionable conclusions about plant samples from a nutritive environment.

From a practical point of view, interesting techniques of culture in columns and vertically in sacks were presented by Italian lecturers. These techniques make it possible to greatly increase production per surface unit.

In summing up this very interesting Congress, it should be noted that, unfortunately, the conclusions presented are too often very localized and, therefore, only have a minimal interest in general terms. In addition, the cost of installation, of infrastructure and even of exploitation are still too high to envisage the widespread use of hydroponics in the near future. It will remain for a long time a technique to be used in isolated and special cases where either the high cost of water for irrigation justifies its use, or else where the desert soil structure makes it necessary to replace the natural soil by the use of a nutritive solution.

The proceedings of this Congress will soon be published and can be bought from the Secretariat of IWOSC, P.O. Bps 52, Wageningen, the Netherlands.

[V - PRYTOTRONS IN THE STUDY OF PLANT GROWTH AND DEVELOPMENT

by L.T. Evans

CSIRO Division of Plant Industry, Canberra, Australia Why phytotronics?

I should begin by confessing to some embarrassment at speaking in a symposium entitled phytotronics, and immediately after such an enthusiast for the word as Professor Chouard. My discomfort arises from the implication that there is a separate science of phytotronics, since I regard phytotrons as instruments, albeit expensive ones, to be used as required by all botanists, as they would use a microscope or an ultracentrifuge. Controlled environment equipment of many kinds has long been available to many plant scientists, and phytotrons differ from this only in their greater scale.

Because of their scale and the great range and combination of conditions they provide phytotrons have, however, become one of the few meeting places for plant scientists of all kinds, from biochemist to taxonomist, and from forester and agronomist to physiologist. They are the agora of modern botany, and perhaps their greatest value lies in the many opportunities they provide for interaction and collaboration between disciplines. The Earhart Laboratory under our chairman, Professor Frits Went, was outstanding in this respect. Hence my concern at the promotion of phytotronics as a separate discipline.

The temptations of diversity

Another danger facing phytotronics *is* too great a delight in the diversity of climatic response among plants. In the course of their evolution, plants have adapted superbly to an extremely wide range of environmental niches, and in doing so have evolved a great variety in their response to the several components of climate. This is evident in their requirements for growth, but particularly in those for reproductive development, as in the daylength requirements for flower initiation in species of grasses and even among races within a species, such as Themeda australis.

It is all too easy in a phytotron to expose and multiply phenomenological diversity to the point where there seems little hope of explaining it in terms of a few general processes. This was certainly true of the daylength-controlled flowering responses of plants, but this diversity of response is gradually being understood in terms of a few general concepts. Given the overwhelming dominance in current biology of the paradigm of molecular biology with its few elegant and universal principles, it is perhaps necessary to be reminded of the other face of biology, the adaptive richness and subtlety of response by organisms to their environment. Provided, of course, that the pursuit of diversity does not become an end in itself.

Sensitivity to climatic conditions

Control of flowering by daylength reveals not only an enormous range of response, but also a quite remarkable sensitivity. Many plants with strict

Photoperiodic requirements for flower initiation, especially those of tropical origin like rice or cowpeas, can detect and respond to differences in daylength of only a few minutes. Likewise, interruption of the diurnal dark period by light for only a few minutes can prevent or cause flowering, depending on the response type. On the other hand, continuous light of very low intensity, comparable to moonlight, is often effective in promoting or preventing floral induction. Also, we now know quite a number of plants which can be induced to flower by exposure to only one short day or one long day. Most of these plants inducible by one day of appropriate length originate from high latitudes; in Polygonum thunbergii, for example, Sawamura has shown that the higher the latitude of origin, the fewer are the short days required for flower induction. Thus, responsiveness to only one short day presumable confers adaptive advantage at high latitudes, quite apart from its convenience for flowering physiologist.

Many of our major crop plants were first domesticated in low latitudes, and were originally strict short day plants (SDP), like rice, maize, sorghum, beans, cowpeas, cotton and potatoes. However, their more recent agronomic development has taken place at higher, more temperate latitudes, and under these conditions cultivars have been selected for relative indifference to daylength. In rice, for example, Katayama has shown that most wild forms are strict SDP, whereas many cultivars are day-neutral and have a shorter life cycle. It is easy enough to see why such changes have occurred, but we still need far more understanding of their effects on the reproductive capacity and yield potential of these crops.

Responses to daylength often display strong interactions with temperature, especially night temperatutre, as in Hyoscyamus (LDP) and Pharbitis (SDP), although in others, like Xanthium and Chenopodium, the critical dark period is little affected by temperature and may be more strongly influenced by endogenous rhythms. Several SDP like cotton, citrus and strawberry, will flower in continuous light when temperatures are low, but only in short days when they are high. Even with these interactions, however, it is relatively easy to extrapolate from phytotron to field for responses to daylength, and phytotron experiments with many plants have led to an understanding of their flowering behaviour in the field.

The ability to control the climatic elements in phytotrons has permitted analysis of the effects of daylength to a degree and with a speed that would have been unattainable in the field. It has also allowed us to resolve which factor governs a response when several covary in nature, as they often do. As an example, consider the duration of grain filling in wheat, the period from anthesis to maturity, which is a major determinant of cereal yields. Field experiments in several countries suggested that this duration was determined by the level of incident radiation, such that total radiation received during grain filling was always about 8.4×10^8 J m^{-2}, but phytotron experiments revealed that it was governed entirely by temperature rather than by the radiation level which frequently varies in parallel with it.

Responses to temperature

Compared with the very plastic responses of plants to daylength, those to temperature are far more conservative. However, even quite small shifts

in ability to withstand extreme temperature can be of great ecological and agronomic significance, and have been sought in many phytotrons. At the high temperature end of the scale, for example, hybrids of Arabidopsis, maize, Phalaris and other plants survive and grow far better than their parents, and my colleague Dr. Langridge has developed an hypothesis to account for this

The Moscow phytotron has been much concerned with survival at very cold temperatures, but I want to consider responses to cool temperatures, in the range 5-15° C. Such temperatures adversely affects chilling-intolerant plants, many Solanaceae for example. The response can be remarkably sensitive, a fall of as little as 0.1 C leading to a discontinuous change in respiration rate and other responses suggestive of a phase change in cell membranes at a critical temperature. The gramnieae may also be separated into two groups on the basis of how temperature affects their rates of growth and photosynthesis. Although the tropical grasses all grow much faster than temperate grasses at high temperatures, at temperatures below about 12° C, they become chlorotic and often die. Early experiments in the Canberra phytotron impressed us with the sharp distinction between the two groups of Gramineae, particularly when Murata and Iyama shortly afterwards reported a comparable difference in the effect of temperature on their rates of photosynthesis. At about the same time, in 1963, Hesketh reported that several Gramineae of tropical origin, such as maize and sugar cane, also differed from temperate plants in that photosynthesis by their leaves was far less subject to light saturation at high intensities. Many years earlier, experiments by Shantz and Piemeisel had shown that many gramineae of tropical origin also had far lower transpiration ratios than temperate plants (50-100 cf 150-250 g water per g dry weight).

Here then was a major difference in the climatic response of plants, of great significance to their adaptation and productivity. How was it to be explained? The answer, as is well known, has come from biochemical analysis of the pathway of CO2, fixation, initiated by Tarchevsky and Kortschak, and resolved by Hatch, Slack and many others. They have demonstrated that in tropical grasses like sugar cane and maize, CO_2 is initially fixed by the enzyme PEP carboxylase, whose affinity for $CO_?$ is far greater than that of the carboxydismutase of the Calvin cycle. This prefixed CO2 is then shunted as malate or aspartate to the bundle sheath cells where the CO2 is released and refixed via the Calvin cycle which can now operate more effectively because of the high CO2 concentrations generated. Hence the reduced light-saturation of photosynthesis, and the reduced photorespiratory loss. This very effective system is, of course, dependent on anatomical differentiation of the leaf tissue to perform the Hatch-Slack C4 cycle in the mesophyll and the Calvin-Benson C3 cycle in the bundle sheath cells. Concentration of this latter cycle in the cells surrounding the vascular bundles is associated with more rapid and complete export of photosynthate from the leaves, hence their faster growth. The more efficient fixation of CO2 mean that the stomata of such C4 plants do not have to open as wide as those of C3 plants to achieve a given rate of photosynthesis, hence their lower transpiration ratios. The real value of the C. pathway lies in the advantage it confers in warm, high-irradiance environments particularly when these are subject to water stress, just as the C_3 pathway is advantageous under cool, low light conditions. However, in spite of all the recent research on the nature of the C_4 pathway, we have yet to explain why C4 plants are so much more sensitive to chilling temperatures.

There are many components of this C4 syndrome, so it is rather striking that the full syndrome appears to have arisen independently among several of the more advanced families of the plant kingdom.

I have dwelt on this matter at some length because it is an outstanding current example of the way in which the various botanical disciplines can help and illuminate one another. It illustrates forcefully how, if we are to understand the climatic responses of plants in more than a phenomenological sense, we need the insights and techniques of all botanical disciplines.

Photosynthetic rate and adaptation

Much of the interest in the C4 pathway has been due to the higher maximum rates of leaf photosynthesis in C4 plants, on the assumption that these must be associated with greater productivity. Hence the extensive screening programmes for C4 forms among C_3 crop plants like wheat and soybean. However, higher rates of leaf photosynthesis do not necessarily confer advantage in terms of either species survival or crop yield. In wheat, for example, the highest photosynthetic rates, comparable with those of C4 plants, are found among the wild diploids, whereas modern productive bread wheat cultivars have much lower maximum rates.

Although differences in the maximum photosynthetic rate of C3 and C_4 plants are striking at the level of the chloroplast or leaf, they may be quite muted at the level of plant communities, as is apparent from a comparison of the maximum crop growth rates recorded for many C and C_4 plants. Partly this is due to the carboxylation resistance being a progressively smaller part of the overall resistance to CO_2 exchange as we approach the level of the plant community, and partly to the fact that in a field crop, there are many leaves at many times of day under low irradiance, in which C_3 plants may have higher photosynthetic rates than C4 plants. It should be clear from this example that even quite major differences in the climatic responses of plants need to be assessed for their impact at the level of the plant community, and that future experimentation in phytotrons must include much more work with simulated communites of plants in spite of the technical problems they pose for effective environmental control.

There are many processes beyond photosynthesis which play a determining role in crop productivity, such as the way in which the plant uses and distributes its photosynthetic assimilates between reserves and investment in new growth of its various organs. In fact, the evolution of crop plants has largely been through the evolution of the sink organs. Climatic factors play a major role in determining the patterns of assimilate distribution, and we need to know by what mechanisms they do so if we are to understand how climate controls plant growth and productivity. But that is the subject of other papers.

VI - OPTIMIZATION IN PHYTOTRONS

by A.F. Klechnin A.V. Malinovski

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The advent of the science of Phytotronics for plant cultures in artificial conditions is linked to the name of an eminent Russian physiologist, the Academician A.C. Famitzin who, in 1865, described an installation which made it possible to cultivate algae, moss and ferns in constant conditions under artificial lighting. As a prototype of Phytotrons for growing higher forms of plants, the growth chambers of Klebs (1914) should be noted. The modern period of phytotronics begins with research by Harvey (1922) who was the first in the history of plant physiology to cultivate plants "from seed to seed" entirely in artificial lighting conditions. Phytotronics received a particularly strong impulsion for its development with the creation of the Phytotron in Pasadena, California, built on the initiative and under the direction of our President, Professor F.W. Went (1943, 1950). We are not going to recount the history of phytotronics here. This has already been done elsewhere by Klechnin (195k, 1960), Radchenko (1967), Strogonov (1967). The latest account has been given by Bilderling (1974).

Our purpose is different. We want to ask questions about new problems facing phytotronics, which, in our opinion, will place plant physiology at a more important level of development.

In modern Phytotronics three directions can be enumerated. The first has as its main preoccupation the creation of constant artificial conditions for plant culture which in nature are particularly variable. Generally, air and soil temperature, lighting intensity, air humidity and sometimes the CO_2 concentration of the atmosphere are stable and controlled. This is realized with the aim of creating the most suitable regimes for one or the other physiologic processes (photosynthesis, growth, development, productivity, etc.).

With this aim in mind, phytotronics seem to have been created and have continued for nearly 10O years. Currently, with the advent of "cold" fluorescent lamps, or else powerful xenon lamps whose spectrum is close to that of the sun, many laboratory installations were set up and became part of most research laboratories, considered as the usual means of plant culture, particularly during winter. This method is beginning to be adopted in azricultural practice, for vegetable production in greenhouses in northern latitudes (for winter tomato and cucumber culture), for floral production (winter bulbous plant culture), for the selection and production of seeds (decrease in the length of selection processes by increasing the number of generations yearly, or else for the multiplication of the most interesting hybrids), etc. These last years we have learned to produce normal plants in artificial conditions at any period of the year. From a scientific point of view, this orientation has probably reached its optimum and it seems that it is no longer necessary to expect new and transcendent results.

A great number of graphs can he obtained which serve to illustrate monographs, but their information value is not very important. The general

character of the graphs which express the link and the dependencies between physiologic processes and exterior factors, are known to us,but the absolute value of the coordinates is filled with unknown factors and depend on a very large number of causes.

The second orientation is only at its beginning. It deals with systems having a programmed direction for factors of the ambient environment, comprising a certain number of sensors which furnish permanent information concerning the evolution of physiological processes and modifications in the parameters of the environment. This new approach *is* currently beginning to be used in laboratory installations on various studies of the life of plants and would have been usefully applied to the entire plant in phytotronic conditions. By closely associating the research of physiologists and mathematicians, a system of differential equations can be obtained which would make it possible to describe plant behavior in an n-dimension space.

We would like to concentrate our attention on the third orientation in phytotronics, which is the direction we have been taking for ten years now (since 1967) at the Plant Physiology Institute of the Academy of Sciences of the USSR and **in which we are currently observing** interesting results.

We think that working **to** create an automatic optimization system for conditions of the ambient environment of plants is one of the major directions for phytotronics.

The main obstacle in the creation of such a system lies in a lack of information about the evolution of physiological processes in plants. However, even if this information is incomplete, in the case of creating bidirectional systems it can be optimized, that is to say, for a system in which directing actions have a double character: they must, in some way, serve research but also, in a certain way, be directing. It is precisely to such systems that experimental Eystems of optimization refer.

The creation of an automation system in which the plant itself chooses its optimal regime concerning the n-factor of the ambient environment is a fascinating problem with an enormous future. The resolution of this problem would have made it possible to activate considerably the research processes for the optimal harmonization of factors of the ambient environment for cultivated plants. This is of even more current interest since, from a mathematical point of view, the problem of optimal regulation is fairly well resolved and the engineering approaches in the resolution of this problem are known. Presently it is research work by plant physiologists which still lags behind.

It is known that the link which exists between most of the physiological processes and the factors of the ambient environment are either extremal curves (fig. la) or either exponential curves (fig. lb). Given the numerous factors of the environment: intensity and spectral composition of light, temperature, amount of CO_2, concentration of mineral elements, pH etc., there are wilco many curves which express factorial links. The problem lies essentially in making the "optimum" points of the various curves coincide between them. The response surface of a plant organism in a plurifactorial space is expressed by a half sphere formed by a large number of individual functions which come together at its summit (fig.2a). In the case of the optimization

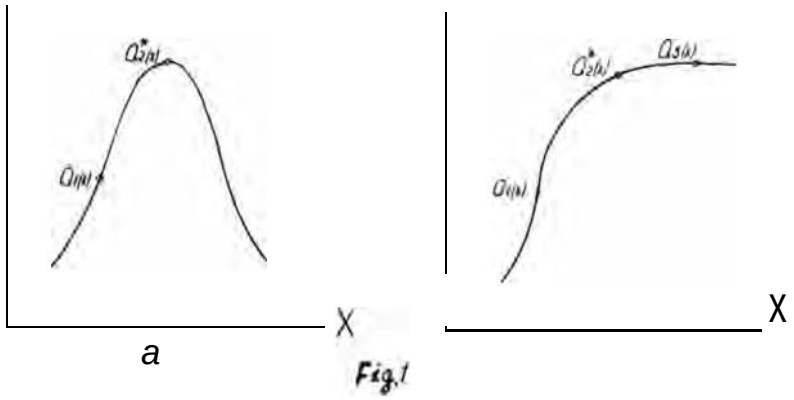
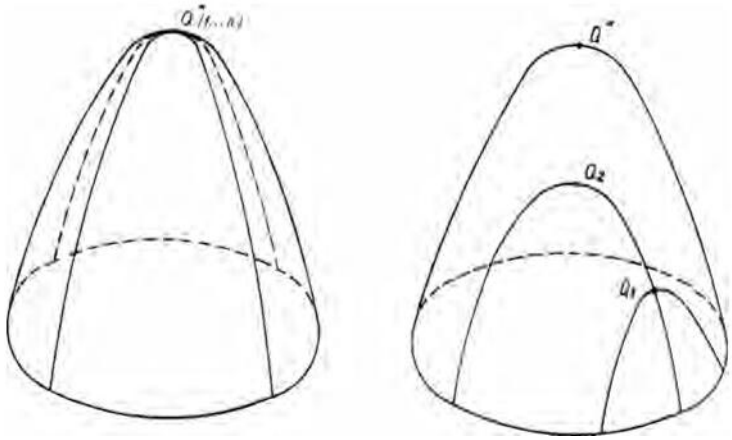


Fig.1

Types of functional liaisons between physiological processes and environmental factors. A : extremal ; B : exponential.



Response surface of physiological processes of a plant organism to environmental factors. A : by optimization for an" environmental factors ; B : by optimization for one environmental factor.

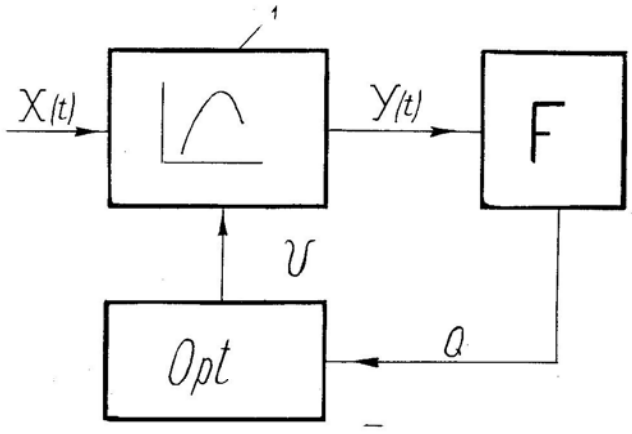


Fig. 3

Scheme of exploratory system for optimise the photosynthesis.

X (t) : Excitation of the subject
U : regulation of the parameters of the subject
Q : control of quality of the subject
Y (t) : exit of the subject
Opt : optimizer
F : former of optimization criteria.

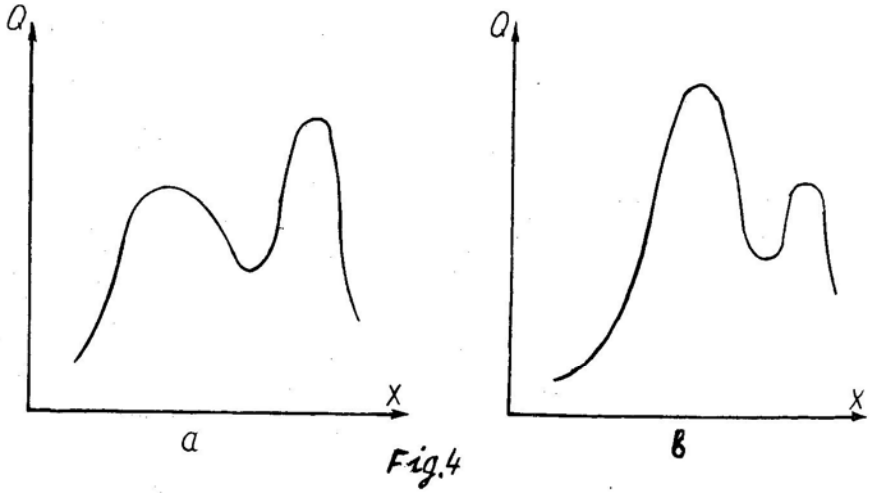


Fig.4

Case of functional liaisons between physiological processes and environmental factors with difficulties for optimization. A : "depth" ; B : "heights".

on a parameter, the coincidence of curves cannot be optimal (fig. 2b). The difficulty comes from the fact that the slope of the curves, the extreme points, the inflection points and the optimal combinations of the curves depend on the initial conditions of the state of the plants and a combination of factors. All this varies according to time, and in a diurnal way, as well during a 24 hour period as during the entire growth period. This is the reason why permanent research for maintaining the optimal combination of environmental factors can only be obtained by means of an exploratory system.

In our laboratory we have elaborated an exploratory system concerning the intensity of light (Korbut 1972, 1973, 1974; Korbut, Klechnin, Malinovsky 1973) and concerning air temperature (Korbut, Aronov 1972; Malinovsky, Klechnin, Korbut 1974; Malinovsky, Korbut 1975). Presently we are proceeding with tests of joint optimization of these factors (Korbut, Malinovsky 1975).

Let us examine the working principle of the systems of exploratory optimization. The subject of regulation - "the plants" - are in an assimilation cell where air temperature or else light intensity can be optimized. The other factors: relative humidity, amount of CO_2 in the air, mineral nutrition, are all stable.

As a criteria for optimization we have chosen the intensity of the photosynthesis, in considering it as the most general index of the "state" of the plant. The problem for the system is the search for and the maintenance of an optimal air temperature for which photosynthesis is maximal permanently. Given the fact that systems of optimization of air temperature and of light intensity are, in principle, not very different, we will only concentrate on an explanation of a working principle for the automatic timization system of temperature.

A diagram of the system is given in fig. 3 and makes it possible to understand the technical principle which serves as a basis for the equipment:

I. Subject cell with the plant. X (t) - excitation of the subject, determined by the metabolic processes of the plant and by exterior agents. Y - Exit of the subject - intensity of assimilation of CO_2. F - former of optimization criteria which realizes the function: and aim of the regulation. Opt - Optimizer that seeks and maintains the values of the optimized factor of the ambient environment U, for which Q is maximum.

The system works in the following manner. In the cell with the plants, air is admitted with a permanent concentration of CO2, equal to 0.03 %. The intensity of the photosynthesis is determined by the difference between the CO2 concentration at the entrance to the cell and at the exit by means of an infrared gas analyzer with automatic recording. The electric signal of the analyzer penetrates into the equipment establishing a criterion of optimizationyan analog computer, which realizes the function of a mathematical transformation of the signal in terms of the criteria of chosen optimization Q. The electric signal penetrates in the optimizer which transmits orders for an increase or decrease of temperature so that Q can be permanently maintained at a maximum.

This system having been described, we will not go into details. We simply note that as a criteria of optimization, not only the intensity of photosynthesis, but any other criteria can be chosen.

The problem of the choice of a criteria of optimization is one of the essential points of the problem. Probably one cannot be limited to one single criteria. In a plant organism there are certainly several. These criteria vary during the growth period and in terms of developmental needs. However, all criterias have an inverse link (for example, the length of the vital cycle). A good harmonization of the factors for a given stage can be shown to be unfavorable in respect to the final result (for example, productivity). The latter can be shown to be more favorable when the point Q2 *(x)* is not maintained but when one of the points Q1 (x) or Q3 (x) are (fig. lb). This is the old problem of the physiologic and harmonic optimum.

The second question concerns the surface of a response. There as well, difficulties exist. When seeking an optimum there will be "depths" (fig. 4a) to surmount and also "heights" (fig. 4b) to attain. These are not metaphors but technical problems for a solution for which special algorithm studies *exist.*

The future of the optimization of physiologic processes probably must be thought of in terms of a combination of several approaches. One of the factors must be stabilized, another must be varied according to a program established previously and a third is optimized by means of a researcher.

The problem of the optimization of the physiological processes of plants is very complex and its resolution is only beginning. It will require much effort by physiologists, engineers, cyberneticians and mathematicians.

We fully understand that our readers may be somewhat disappointed by our presentation: we have raised a great number of questions and we have answered only some of them. We do this knowingly. The problem before us is important and very difficult to resolve. We only presume to pose the problem. Its resolution will require the work and collective efforts of a great number of researchers in many countries.

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VII - UTILISATION OF PBYTOTRON FOR INVESTIGATION OF PLANT VITALITY

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For the estimation of coenosis gas exchange, it is necessary to know different aspects of photosynthetic and respiratory activities determined by dynamics and kinetics of these processes depending on specific and ontogenetical characteristics of plants under different growing conditions.

The overall amounts of carbon dioxide, assimilated by coenosis during vegetation, are determined to a great extent by the regularities of daily and age dynamics of photosynthesis and respiration of coenosis under choosen growing conditions. Despite the great number of investigations carried out in the field experiments or under partial stabilization of growing conditions, it is impossible to distinguish with sufficient validity the action of exogenous and endogenous factors on photosynthesis and respiration which is essential for estimating the nature of transformations and estimating the ways for control of photosynthetic and respiratory activities of plants. Dependence of these processes upon the structural features of coenosis determines the necessity of investigation of the dynamics of gas exchange at a level of phytocoenosis.

In connection with the insufficient knowledge and the importance of elaboration of these questions, we carried out an extensive investigation of dynamic characteristics of coenosis gas exchange of different cultures under the constant conditions of phytotron. In view of that, we developed and created hermetic phytotrons, which ensured absolute control of parameters of environment.

In the phytotron with the cultivated ares of 0.25 m2 and the capacity of 0.25 m3 (fig. 1), we carried out more than 100 experiments. The aim of investigations was the study of daily and age dynamics of coenosis photosynthesis and respiration for different durations and intensities of irradiation.

The temperature in phytotron varied from 18° to 25° C, +/- 0.2° C and relative humidity of air from 40 % to 70 %, +/- 7%. Registrations and regulations of CO_2 concentrations were made by infrared gas analyzer LIRAS and its secondary device. The secondary device sets limits of gas concentration alterations in the vegetative chamber air.

Gas discharge xenon lamps DKCIB-6000 were used for the lighting of coenosis. They made it possible to obtain the intensity of light up to 500 w/M^2 in the region of PAR.

We worked out methods of adjustment of CO2 and O2 concentrations in the air media to the last details with the help of the installation. These methods were used in subsequent structures.

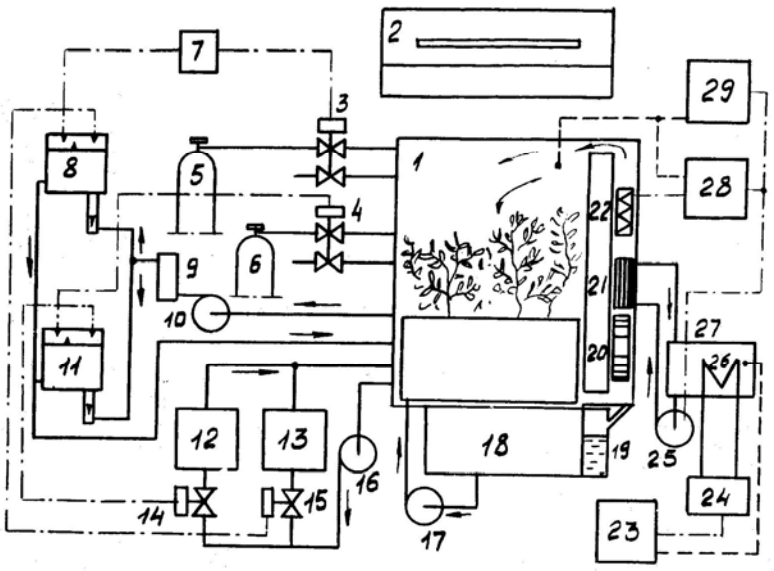
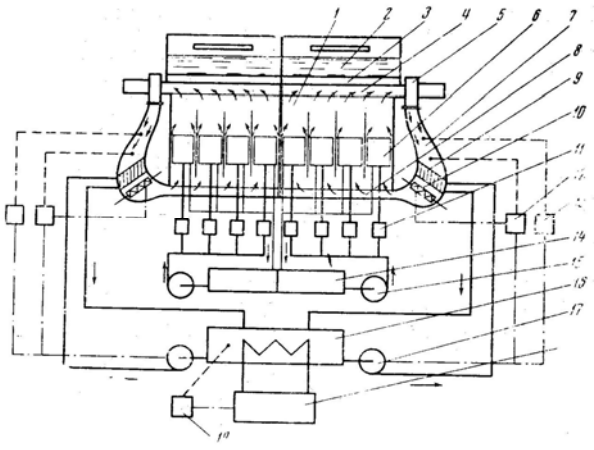


Fig. 1 - Scheme of phytotron. 1) Vegetative chamber. 2) Light screen. 3) Electromagnetic taps for CO2 supply. 4) Electromagnetic taps for 02 supply. 5) Cylinder for CO2. 6) Cylinder for 02. 7) Time relay for CO2 supply. 8) Gas analyser for CO2. 9) Gauge of consumption. 10) Blower. 11) Gas analyser for 02. 12) Absorber for 0_2. 13) Absorber for CO2. 14, 15) Electromagnetic taps for absorbers. 16) Blower. 17) Fluid-flow pump. 18) Container for nutrient solution. 19) Capacity for collection of transpiration moisture. 20) Centrifugal blower. 21) Cooler. 22) Heater. 23) Thermoregulator of cooling brine. 24) Refrigerating aggregate. 25) Fluid-flow pump. 26) Heatexchanger. 27) Container for cooling brine. 28) Regulator of air temperatures in the chamber. 29) Regulator of air relative humidity.



Note : Arrows show directions of liquid and gas flows.

Fig. 2 - General scheme of ventilation, air-conditioning and system of feeding in the installation.

1) Hermetic chamber. 2) Light screen with water filter. 3) Liquid filter. 4) Air pickup. 5) Ventilator. 6) Vegetative cuvette. 7, 8) Air-suppliers. 9) Heatexchanger. 10) Heater. 11) Electromagnetic valve. 12) Temperature detecting element. 13) Humidity detecting element. 14) Container for nutritive solution. 15) Fluid-flow pump. 16) Container for water cooling. 17) Fluid-flow pump. 18) Refregerating aggregate. 19) Semiconducting thermoregulator.

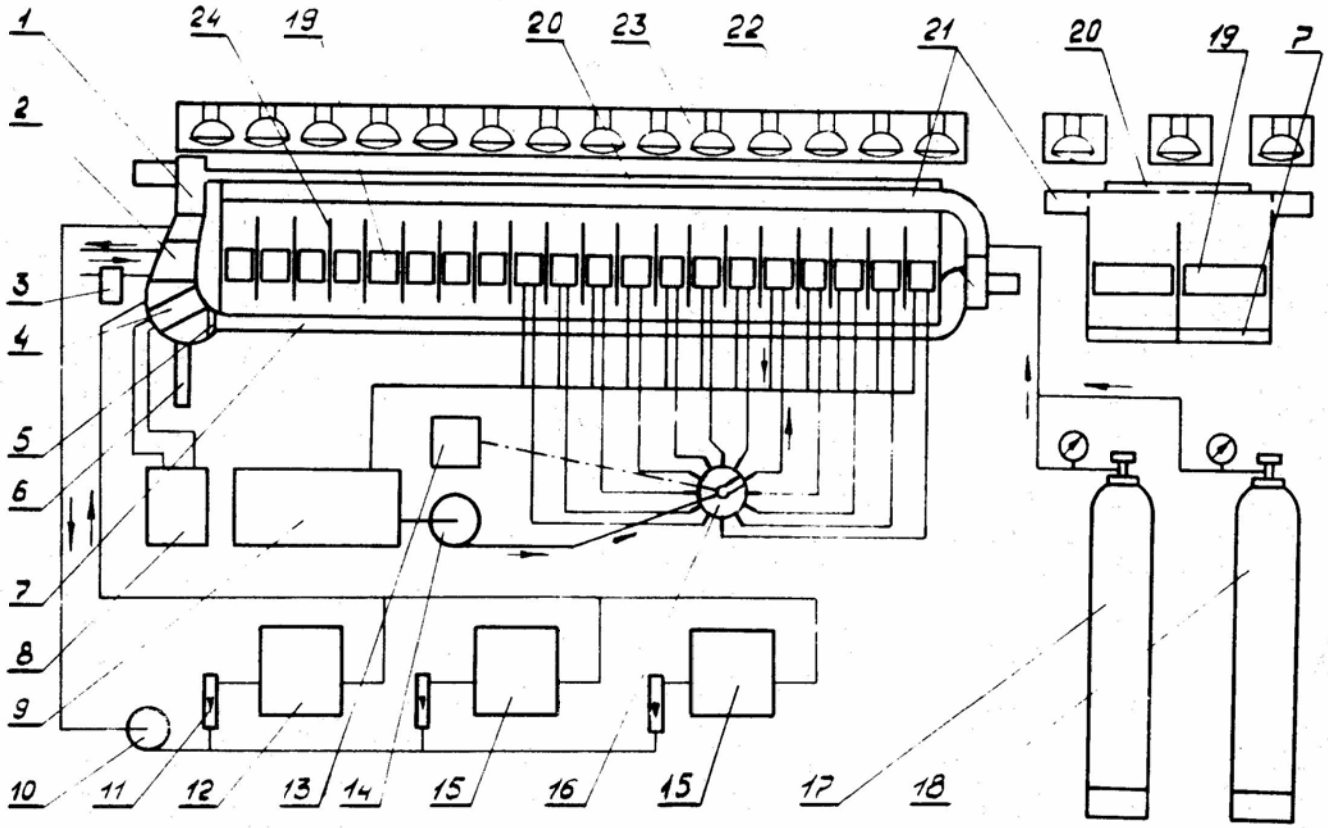


Fig. 3 - Scheme of phytotron for the study of compatibility of plants to nutrition and gas regimes.

1) Centrifugal ventilator. 2) Heatexchanger for adjusting air temperature in the chamber. 3) Electromagnetic valve for cold water supply. 4) Heatexchanger for removing of moisture. 5) Heater. 6) Capacity for collection of transpiration moisture. 7) Air-supplier for even distribution of air inside the chamber. 8) Refrigerant aggregate. 9) Container for nutrient solution. 10) Blower. 11) Gauge of consumption. 12, 15) Gas analysers for O_2, CO_2 and N_2. 13) Drive of rotor tap. 14) Pump for supply of nutrient solution. 16) Rotor distributive tap. 17) Cylinder for CO_2. 18) Cylinder for O_2. 19) Vegetative cuvette. 20) Upper air-supplier for steady air supply. 21) Side air suppliers. 22) Subsidiary centrifugal ventilator. 23) Light screen. 24) Transparent partition. 25) Electromagnetic taps for CO_2 and O_2 supply.

The installation with two similar phototrons (fig. 2) enabled us to carry out experiments in twofold replications. Each phytotron consists of a hermetic chamber with the cultivated area of 0.5 m2 and with the capacity of 438 litres. They have automatic systems of nutritive solution supply, of gas regulation, air _conditioning, lighting.- The temperature in chambers is regulated and is maintained within. 16°-28° C, +/- 0.1° C, under relative humidity of air varied from 40 % to 80 %, + 7 %7The system of lighting permits to produce the capacity of light flow of 500 w/m^2. The construction gives a chance to change rapidly the sources of light.

For the study of plants compatibility of different species and ages for gas regimes and nutrition, the phytotron was created with the cultivated area of 5 ^{m2} and the capacity of 5.4 m3 (fig. 3). In this phytotron, temperature was maintained from 18° to 25° C, +/- 0.2° C, relative air humidity from 60 to 90 %, +/- 7 %. The capacity of light flow reached 400 w/M^2. The system of nutrient solution supply made it possible to grow plants by aero- and hydroponics. The plants were grown in cuvettes, which could be moved on vertical line with the aim of creating similar light regimes for each plant of coenosis on the level of upper leaves.

Nutrient solution supply is automatic and is performed individually into each vegetative cuvette by means of a distributive rotor tap (fig. 4 shows only a part of nutrient system). The adjustments and measuring of concentrations of gas components are carried out in three indices, namely oxygen, carbon dioxide and nitrogen by corresponding gas analyzers.

Our experience concerning the creation and utilization of different installations for biological investigations enabled us to formulate the technical task for designing and manufacturing the hermetic phytotron with useful cultivated area of 1 m^2 and air capacity of 1.2 m^3 (fig. 4).

Unlike the former installations in this phytotron, nitrogen content in the air of chambre is recorded within 65-85 % (volumetric per cent) to an approximation of + 1.5 % from measured value. It can be recorded the level of nutritive solution in the tank with an electron device having the compass of dimensions from 0 to 95 1. With an approximation **of +/- 1 1.** Given the temperatures and the humidity, as well as the concentrations of carbon dioxide and oxygen, one can stay within the root zone.

The system of thereto- and moisture-regulation of the phytotron has two channels, namely the temperature regulation and the moisture regulation: Actuating mechanisms are accordingly to the brine exchanger through which the main flow of air is blown and the evaporator of refrigerating aggregate drying a part of the main flow. The moisture condensing on the evaporator pours down into a special hermetic tank. There are sprinklers in the hermocamera of phytotron for the moistening of the air, they are in the channel for recirculation of air. Signals for functioning of these mechanisms come from secondary sensing elements of temperature (resistance thermometer) and humidity (hygroscopic sensitive element with lithium chloride). The temperature adjustments of the air in the **chamber** are changed withing the limits of +15° C to +45° C to an approximation of +/- 0.2° C; humidity is maintained within the limits of 60 %-90 % to an approximation of +/- 7 %. The range of adjusted temperatures in the root zone includes 10° to 30° C, within +/- 1° C.

For the measuring and recording of the concentration of carbon dioxide in the chamber and the root zone of plants, optical-acoustic gas analyzers OA-2209 are used with the range of scale changing from 0 to 1 % CO_2 (volumetric) and for oxygen thermomagnetic an apparatus MN5122 is used having the scale from 18 to 23 % 0_2 (volumetric). Oxygen consumption is based on oxydation of copper protoxiae.

Six xenon lamps DKSTV-6000 are used as a source of radiant energy for growing plants.

Ray filters SZS-25 are used for the restriction of spectrum (with the wave lengths below 300 and over 800 nm); they are introduced into the vegetative chamber. Distilled water in the housing of illuminator passes through **a** cooling syStem, which is automatic and maintains the temperature of water at the given level. The capacity of radiant energy is adjusted within the limits of 50 to 450 w/M^2. In the installation, it is possible to grow plants by two methods, namely by hydroponics with substratum under low flooding and by aeroponics.

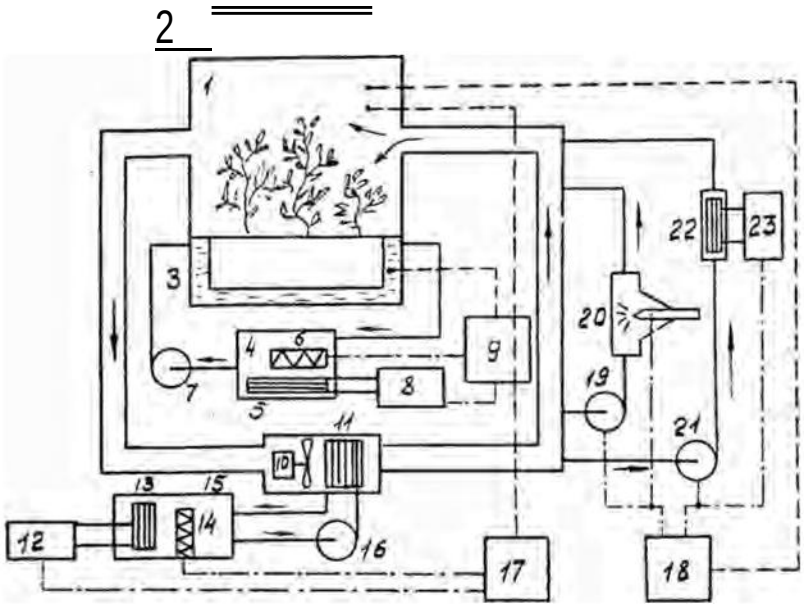


Fig. 4 - Scheme of adjustment of temperature and humidity in the phytotron with cultivated area of 1 mZ.

1) Vegetative chamber. 2) Light screen. 3) Vegetative bath with thermoregulator. 4) Block for thermoregulation of brine in the vegetative bath. 5) Cooler. 6) Heater. 7) Pump. 8) Refrigerating aggregate. 9) Thermoregulator of vegetative bath. 10) Ventilator. 11) Exchanger. 12) Refrigerating aggregate. 13) Cooler. 14) Heater. 15) Brine block for thermoregulation of air in the chamber. 16) Pump. 17) Air thermoregulator. 18) Regulator of relative humidity of air. 19) Blower. 20) Moistener. 21) Blower. 22) Exchanger of moisture removal. 23) Refrigerating aggregate.

VIII - AUTOMATIC CONTROL OF LIGHT INTENSITY AND SPECTRAL COMPOSITION USING SMALL COMPUTER

by Tsuyoshi MATSUI, Hiromi EGUCHI, Yasuhiko SOEJIMA and Michio HAMAKOGA

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SUMMARY

A radiation system with automatic control of intensity and spectral composition of light in a growth cabinet was developed. Feed-forward system with an on-line computer was adopted for control of spectral composition, combining the feedback system of light intensity control. This system made it possible to change the spectral composition in time series under keeping desired intensity of light. The performance resulted in promoting a new method of artificial light radiation to plants.

x

In a previous paper 4) , we reported on an instrument for artificial light radiation in a growth cabinet. This instrument made it possible to give both optional intensity and spectral composition of light to plants, and reliable performance was brought. The present paper deals with development **of** the system of automatic control of light for plants in a growth cabinet 'and with the analysis of its characteristics for the purpose of variable value control of both intensity and spectral composition of light.

Lighting system. Six kinds of lamps (10 blue, 10 blue-white, 10 yellow, 10 pink and 5 red fluorescent lamps of 110 W extra-high-output, and 10 red beam lamps of 100 v-100 W) with individual spectral emissions were used as the light sources of the instrument as described in the previo4s paper. They were provided in the lamp compartment of the growth cabinet. 2) The light output of individual lamp was independently controlled in the range from 0 % to 100 % of rated capacity, using SCR manipulators for varying the effective current through the lamps. Both light intensity and spectral composition at plant area in the growth cabinet were controlled by means of varying the light output of each lamp. The feedback and feed-forward controls were applied to this system.

Measurement methods. Light intensity was detected by a radiometer (RMA-8, Japan Spectroscopic Co., Ltd.) and used as the feedback signal. The time constant of the radiometer system, which is changeable, was selected at 10 sec in the present experiment with the notice of the matching to the process. The controlled variable of light intensity was monitored by a fast responding system, RMD-1 radiometer (JASCO) with the time constant of 0.025 sec. A vacuum thermocouple of Schwartz type was used as the detector in these radiometers, which has equal response to wide range from 250 nm to 2.500 nm. In front of the thermocouple, a heat-absorbing glass (Heat Glass, Ohara Optical Glass Mfg. Co., Ltd.) was fixed in order to eliminate the long wavelength

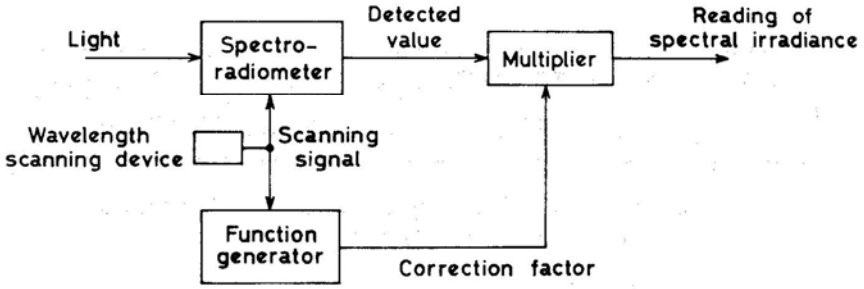

Fig. 1 - Block diagram of the improved spectroradiometer.

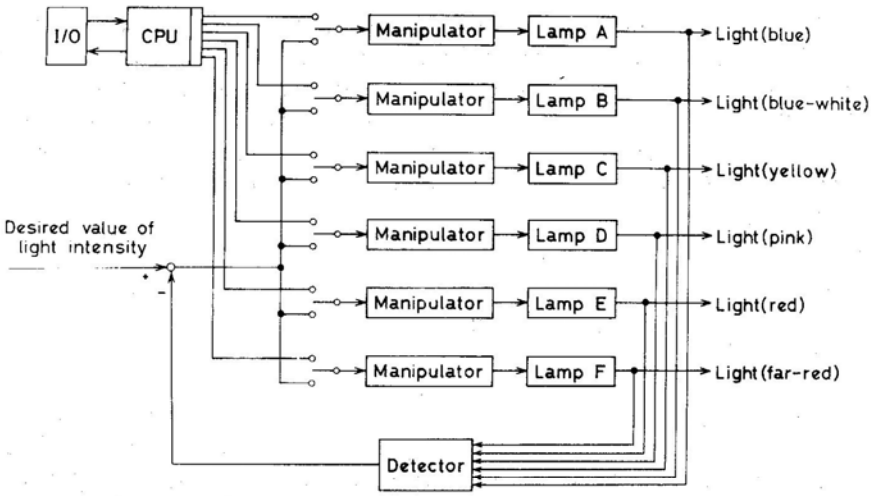

Fig. 2 - Block diagram of feedback and feed-forward control of light.

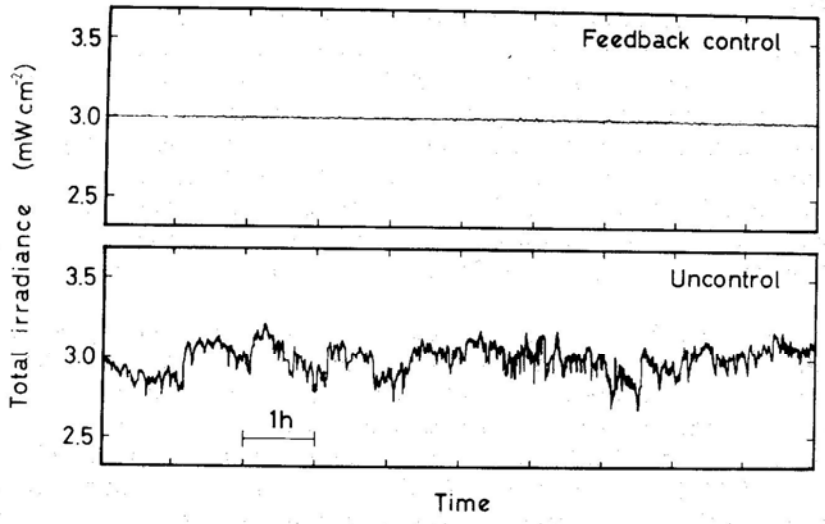

Fig. 3 - Comparison of total irradiance between feedback control and uncontrol.

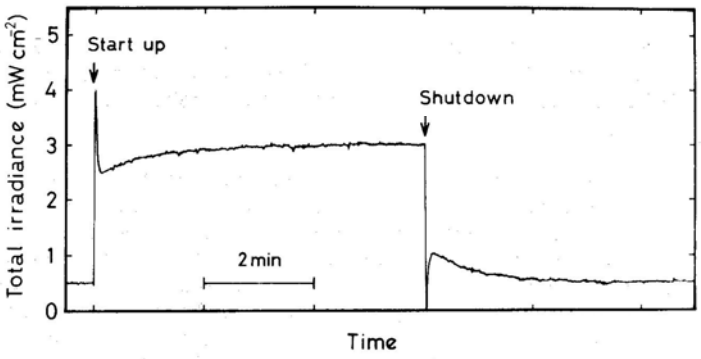

Fig. 4 - Step response (0. 5-3.0 mW/cm^2) in feedback control of total irradiance.

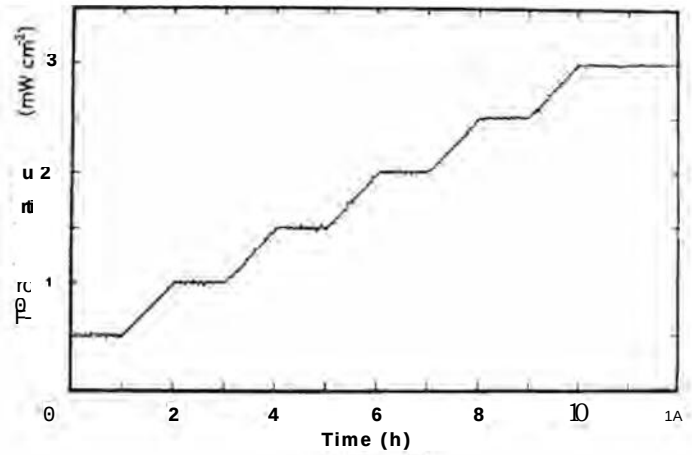

Fig. 5 - Ramp response in feedback control of total irradiance.

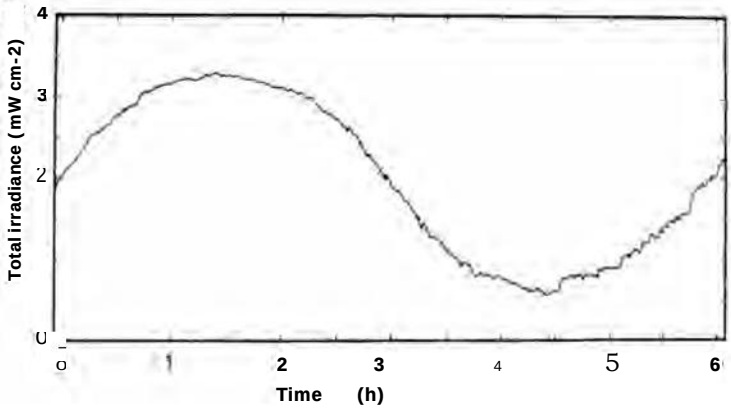

Fig. 6 - Feed-forward control of total irradiance with the desired value of I = 1.25 sin 60 T -1- 2, where I is total irradiance (mW/cm^2) and T is time (h).

of light, so that this radiometer was able to measure the integrated power in the wavelength range from 300 nm to 800 nm. The light intensity was defined as the total irradiance by means of this integrated power in the present study.

Spectral composition was evaluated as the spectral irradiance. An improved type of spectroradiometer [4] was used for measurement of the spectral irradiance. Figure 1 shows the block diagram of the spectroradiometer. Spectral response in the spectroradiometer was affected by spectral transmissions of integrating sphere (light receiver) and monochrOmator, and by spectral sensitivity of photomultiplier cathode. In this instrument, the detected value was automatically corrected with using electronic components of a function generator (FT-3, Riken Denshi Co., Ltd.) and a multiplier. The drive of function generator was electronically synchronized to the wavelength scanning in the monochromator. The detected value was corrected by multiplying by the correction factor generated on the basis of the spectral response in this radiometer. Thus, the absolute value of spectral irradiance was directly recorded without any manual correction. Sighting angle of the spectroradiometer was limited to about 40° with the shade attached to the entrance aperture of integrating sphere for adjusting cosine response to the radiometer. A heat-absorbing glass was also attached to the aperture in order to make similar spectral response of both radiometers.

Feedback control. Light intensity was controlled with using the total irradiance as the feedback element which was detected by the radiometer at a central position in the growth compartment. The total irradiance was evaluated as 0-10 mV/0-5 mW/cm^4, and used as the feedback signal led into a PID controller (EGC, Yokogawa Electric Works, Ltd.). The PID parameters were set at 85 % (PO, 1 min (T_1), and 0 min (T_D), respectively. A programme generator (PGE-14, YEW) was connected with the PID controller.

Figure 2 shows the block diagram of the light control system. When switching onto the feedback circuit, the light output was compensated to satisfy the desired value of the total irradiance. The light output of each lamp was controlled at the same ratio of the rated value. The light intensity was usually fluctuated under uncontrolled copdition because of the changes of electric power and the other factors.[1] Figure 3 shows the total irradiances in an uncontrol and in the feedback control. The fluctuation of the total irradiance was 10 % of full scale in an uncontrol system, but was reduced to 1 % in the feedback control. A step response in feedback control of the total irradiance is shown in Figure 4. In this step response, the overshoot was observed. The delay time was remarkably small, and the settling time was about 5 min. The variable-value control was made possible by setting the desired value of the total irradiance in the programme generator. Figure 5 shows the ramp response as an example of the variable-value control. The response was successfully fitted to the desired value in time course.

Feed-forward control. An on-line digital computer system [3] was adopted for the feed-forward control. The desired value of light output was programmed and put into CPU through either tele-typewriter or photoelectric tape reader. Computed value was converted into analog value through DA converters, and used as the manipulating signal. This system provided six DA converters corresponding to the six kinds of lamps. The light output of - lamps to be controlled, was decided by messages in the program to select appropriate DA converters.

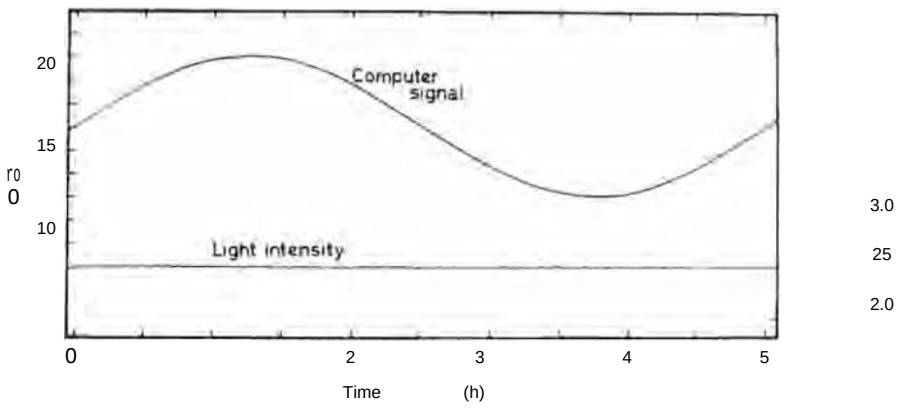

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Fig. 7a - Total irradiance controlled at 2. 5 mW/cm by combined feedback and feed-forward control system ; where variable-value controls of light outputs of both blue and blue-white fluorescent lamps were carried out with sine curve from the computer, and the others were controlled by feedback system.

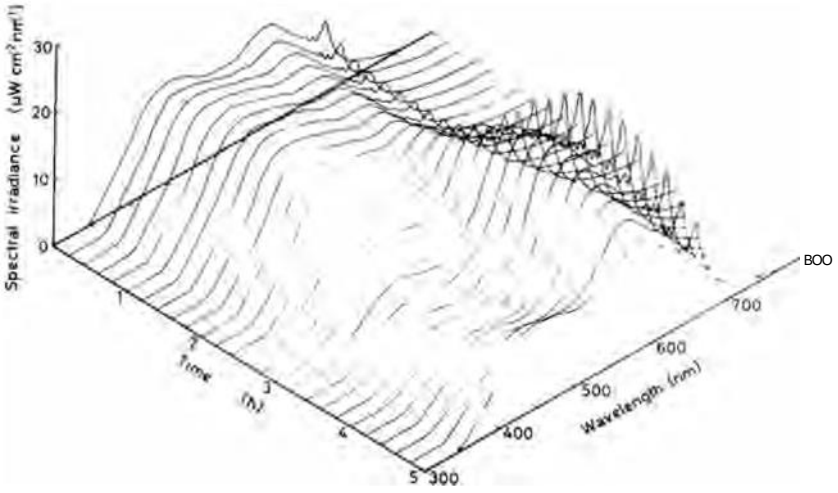

Fig. 7b - Variable-value control of spectral irradiance with combined feedback and feed-forward control system ; where control condition was the same as that in Fig. 7a with the exception of mercury lines.

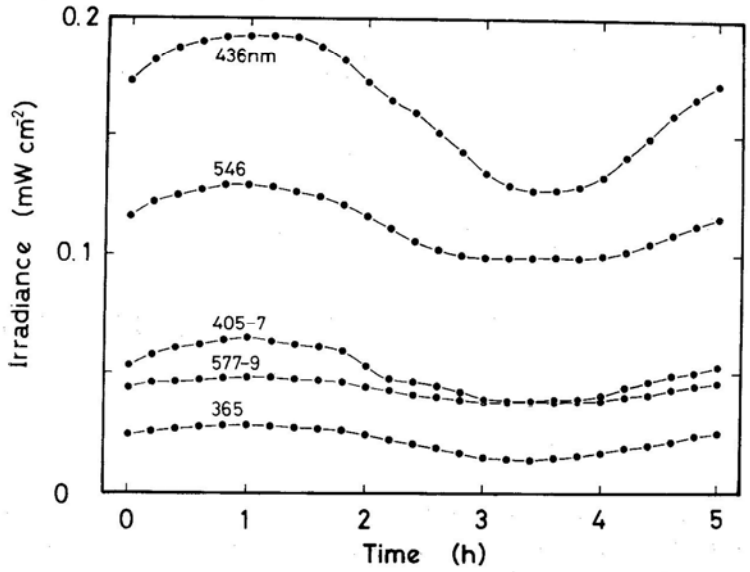

Fig. 7c - Changes of irradiance of mercury line in combined feedback and feed-forward controls.

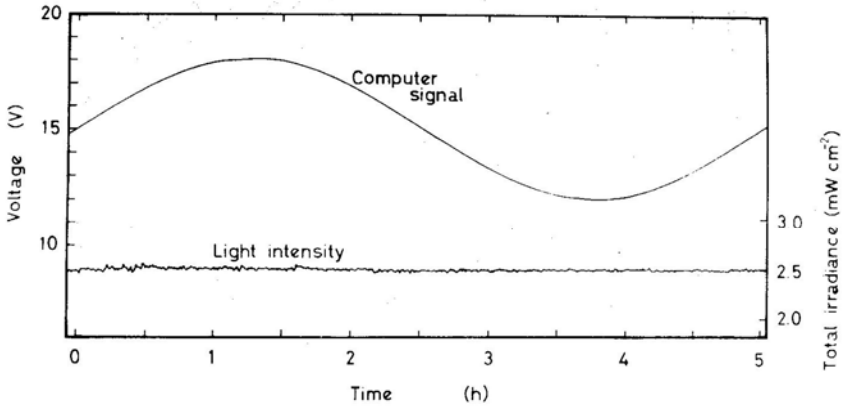

Fig. 8a - Total irradiance controlled at 2.5 mW/cm^2 by combined feedback and feed-forward control system ; where variable-value controls of light outputs of both yellow and pink fluorescent lamps were carried out with sine curve from the computer and the others were controlled by feedback system.

Figure 6 shows the feed-forward control of total irradiance, when the light outputs in the whole of lamps were controlled by the computer, with programming the desired value of I = 1.25 sin 60 T + 2, where I is total irradiance (mW/cm^2), and T is time (h). The response was almost reliable. However, there was some fluctuation (+/- 0.1 mW/cm^2) in a controlled variable, because the feedback circuit was switched off in this case.

Combined feedback and feed-forward control system. As shown in figure 2, light outputs were controlled by feedback, feed-forward, or combined these systems. In the combined feedback and feed-forward control system, variable-value control of the spectral composition was achieved under keeping desired total irradiance. The two circuits were selected by operating switches onto feedback or feed-forward system.

Figure 7a shows the total irradiance controlled at 2.5 mW/cm2 by combined feedback and feed-forward control system; where variable-value controls of light outputs of both blue and blue-white fluorescent lamps were carried out with sine curve from the computer, and the others were controlled by.feedback system. Variable-value control of the spectral composition was performed as shownin Figure 7b, where the spectral irradiance was measured at the intervals of 12 min. It is obvious that the irradiance in longer wavelength region varied in inverse proportion to that in shorter region under the constant total irradiance. The value of area by means of integration of spectral irradiance from 300 nm to 800 am was mostly equal to the desired value of total irradiance within the deviation of 0.5 %. Thus, even if the spectral composition changed in time course, total irradiance was kept at the desired value of 2.5 mW/cm^2 with reliable condition as shown in Figure 7a. In this case, the irradiances of respective mercury lines were changed as shown in Figure 7c.

Another example of combined feedback and feed-forward control is shown in Figure 8, where light outputs of both yellow and pink fluorescent lamps were controlled by the computer under constant total irradiance controlled by the feedback system.

Thus, the automatic control of total irradiance and spectral composition was achieved with optional desired values and was considered to be available for radiation to plants with time series of those factors.

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x

IX - THE IMPORTANCE OF A SPATIAL STRUCTURE FOR ARTIFICIAL LIGHTING IN PHYTOTRONS

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Researche during these past years have shown the importance of a spatial distribution of the light radiations arriving on the plants. This light factor acquires a special importance with the use of powerful light sources in the plant growth chambers where either solar light does not exist (Phytotron growth chambers) or where this light is too weak (greenhouses during winter period).

The rapid development of the use of powerful electric lamps of 5, 6, 10 KW and even more, increases the requirements relating to the orientation of the light radiations. This is linked to the need, first of all, for increased efficiency in electric energy expenditure per unit of culture, and in the second place, to the problem of obtaining uniform plant material (relating to the form, dimension, desired yield and dynamic in the unrolling of the various phenological phases).

The researche undertaken at the Artificial Climate Laboratory ofthe K.A.Timiryazev Agriculture Academy in Moscow, since 1970, gives some idea of the reactions of various plants to the distribution of incident light radiations (Fantalov et al. 1970; Leman et al. 1975).

Method: As subjects we chose monocotyledon and dicotyledon plants. In the first group we had a short stem wheat and a dwarf spring wheat, in the second group: tomatoes, green beans, cucumbers, lupins and sunflowers. The plants are grown in hydroponic on granitic gravel in fixed cups where a Knop solution is admitted every 4 hours to humidify the root system for 9 minutes. The light source used was formed by two 6 KW water-cooled Xenon

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amps of the type DYCTB-6000, of which the light radiation is formed and directed by means of corrective layers on the glass envelope of the lamps. The main subjects of the radiations were formed by 2 directional patterns (Table 1) with an identical horizontal luminosity.

Table 1

Characteristics of basic irradiation patterns of the plants

Pattern	Directional distribution of light flow around the plants.	Values of the flow component directed: from left, above, and right (in % of resulting flow)
I	single direction: from above	0 - 100 - 0
II	two directions on opposite sides with an angle of 45° with respect to the horizontal	50 - 0 - 50

In the different experiments, the values of the various light flow components changed very slightly: 30 - 0 - 70; 40 - 0 - 60 and 33 - 33 - 33. But, since the results obtained for these various cases of irradiation have not fundamentally diverged from the results of pattern II, we are not going to describe them in this paper.

The period of lighting chosen was 16 hours per day. Air temperature around the plants: 23° C during the day and 16° C during darkness, with a variation of 1-2° with respect to the set value. Relative humidity of air was 50 to 70 %.

Results:

A-Dicotyledon plants. Our results show clearly the growth and development reactions of dicotyledon plants towards the direction of the light flow.

Table 2 shows that irradiation of plants with powerful lamps from above (as is frequently the case with artificial lighting) produces an excessive elongation of the stem and the other organs. In the case of a two-side lighting, such a reaction is only observed if there is a predominant lighting from one side. Only a uniform distribution of two (or more) lateral flows will assure the regular formation of dicotyledon plants.

B-Monocotyledon plants. The analysis of the results obtained (table 3) shows, with the system of directional light radiations from several light sources, important difference on the normal formation of cereals and on their

yield. For the 2 kinds of wheat, an increase of twice the plant tillering is characteristic in the case of plant lighting by means of a double luminous flow as compared to subject 1, where the plants are lighted by a single direction flow, even for the same horizontal lighting.

Table 2

Characteristics of irradiation conditions and average value obtained with the plants

lighting conditions		average values of biometric indexes			
irradiation pattern	resulting horizontal flow (Klux)	plant height in cm. (mm)	diam. under cotyledon	number of leaves	dry weight aerial part (g)
		- Tomates "Pouchkine 853" 24 days			
I	10.0	35.4	6.0	9	1.62
II	10.0	19.6	6.2	9	1.76
		Cucumbers "Several fruits Marfino" 24 days			
I	10.0	3.9.1	7.2	5	2.40
II	10.0	27.2	7.9	5	2.31
		Sunflower "Yugovostotchny" 27 days			
I	15.0	69.9	9.8	12	4.96
II	15.0	66.8	10.5	13	5.75
		Lupin "Severny" 27 days			
I	15.0	59.8	2.9	18	1.09
II	15.0	52.4	3.4	19	1.22
		Green bean "Saxe without fibers" 23 days			
I	10.0	95.5	*3.4*	5	2.98
II	10.0	63.1	4	5	2.97

This difference, which can be observed on the entire plants, as well as on a group of tillers with ripe seeds, made it possible in subject II to achieve a total plant productivity increase (number and weight of ripe seeds) of more than twice. The weight of 1000 seeds has increased. It gave (in grams):

		I	II
wheat	"1812"	43.1	45.3
"	"CB-151"	30.7	34.9

Table 3

Influence of the lighting method on the dimensions and the yields of wheat plants

irradiation pattern	height of plant (cm)	weight of aerial part (g)	number of stems	seed yield		weight of 1000 seeds (g)
				number	weight (g)	
			" World seeds 1812 "			
I	74.5	7.90	3.8	76	3.12	43.1
II	75.8	16.20	8.0	147	6.15	45.3
			" Canada-CB-151 "			
I	30.5	1.70	2.1	23.6	0.76	30.7
II	32.1	4.42	4.0	62.3	2.11	34.9

Besides a superiority of these plants in the production of organic matters, it should be noted that the development of the different phenological phases is faster and that the formation of the various leaves is also faster. Thus, the phase of waxy ripeness in subject II started 4 to 6 days before subject I. At the same time, important differences in plants of the two subjects have been established, relating to the following indexes: height of plant, number of leaves, length and number of seeds per stem, content of chlorophylle and carotenoids, etc.

The plants we have obtained perfectly resemble those harvested in the fields in summer. Wheat plant CB-151 grown in cenose, has also shown a greater advantage for bilateral lighting on the number of productive stems (1.5 tines)

and an earlier waxy ripeness - 72 days after the spearing; plants with unilateral light were approximately 8 days late. The delay in development of cenose plants, with lighting only from above, started with the third leaf. Ten days after the spearing, 20 % of the plants of subject I showed the appearance of the third leaf, whereas with bilateral lighting, 3 leaves at the same time appeared in 77 % of the plants (Table 4).

Table 4

Dynamic of the evolution of the various development phases of wheat CB-151

Age of the plants (days)	Development phase	Dynamic in %	
		Subject I	Subject II
10	3rd leaf	20	77
14	4th leaf	35	98
17	5th leaf	5	72
30	ascent	70	100

Subsequently, a delay in the development of plants with lighting from above only was also observed: at the time of flowering, 7 days and at the time of milky ripeness, 9 days,

Thus, with wheat the most characteristic index of lighting conditions in a system of powerful directional light flow, is the number of productive stems, and consequently the seed yield. In case of a horizontal lighting of the same intensity, this index is far higher for plants receiving the light flow from two or more sides than for plants receiving the light flow from only one direction.

Conclusions

1 - When powerful lamps are used in phytotrons, the growth and the development of the plants are strongly influenced by the direction of the light flow.

2 - Two types of reactions have been observed with plants: dicotyledon plants (tomatoes, green beans and others) show modifications in the axial organes; monocotyledon plants (wheat) show an increase of the number of productive stems

and consequently of the seed yield. In both cases there is a shortening of the growth period.

3 - The distribution of the light flow on the plants in the case of artificial lighting culture can be a compensatory complement when lighting is insufficient (with respect to the summer) and the spectral composition of the light energy arriving on the plants.

By varying the spatial structure of the light flows directed on the plants, their process of formation and their productivity can be actively influenced, which allows us to draw the following conclusion: the light flow distribution acts as a regulator of physiological processes.

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x

X - RAISING THE PHOTOSYNTHETIC PRODUCTIVITY OF PLANTS **AS A RESULT OF THE INTENSIFICATION OF THEIR ROOT NUTRITION** UNDER OUT-DOOR HYDROPONICS

by G.S. DAVTYAN

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The investigations of agrochemists, plant physiologists and engineers of various specialities during the last 10-20 years have revealed great possibilities for the soilless production of plants under conditions of a regulated technology of commercial hydroponics.

Hydroponics is the logical continuation and industrial achievement of agrochemical science. The discoveries and investigations carried out by Lavoisier, Boussingault and Liebig, Salm-Horstmar, Krim, Sachs and Helriegel, Loose and Gilbert, Mendeleev, Timiryazev, Pryanishnikov, Gedroyts and a brilliant multinational galaxy of many chemists, agrochenists and botanists, secured the formation of the orderly theory of mineral nutrition to which mankind owes so much for the unprecendented development of rational agriculture.

However, the significance of this over-all biological theory lies also in the fact that already in our times it opened up the road to a new branch of production on the junction of industry and agriculture, to the commercial hydroponics - to the new, supplementary field of biological industry.

This new field of the soilless production of plants does not contradict, but rather presupposes the further industrialization and development of traditional agriculture in its turn.

The practical significance of commercial hydroponics increases further if one takes into account that it does not need fertile soils; it may be organized on territories which are unfertile and unused for plant production, such as malignant soda soloncheas, stony grounds, and even on the roofs of industrial or residential in huge buildings.

The results of nineteen years of experiments have shown not only the possibility of the hydroponic production of most different plants (beginning from flowers and vegetables and ending up with vines and peach tze4.e0 ; *knir* also the possibility of a multiple increase of their productivity under out-door gravel hydroponic conditions (Table 1).

The raw material often *grows* in greater amounts, from 5-10 times and even more.

Hydroponics has become a commercial possibility; K.A. Timiryazev's prediction was justified; it was he who, way back in 1876, in his lectures on plant life, described the methods of their growth without soil, on artificial media, "with sand, pumice crumbs, glass beads" by means of feeding them with the nutrient solution with a concentration of about 0.2 %. K.A. Timiryazev showed even in those days the possibility of the industrial application of that method "in the future". And now here it is, that "future" has already come.

Many are the factors conditioning the multiple increase of the productivity of plants under out-door hydroponica. We have tried to systematize this question in the report read at the IV International Symposium on industrial plant production, held in Vienna in 1971.

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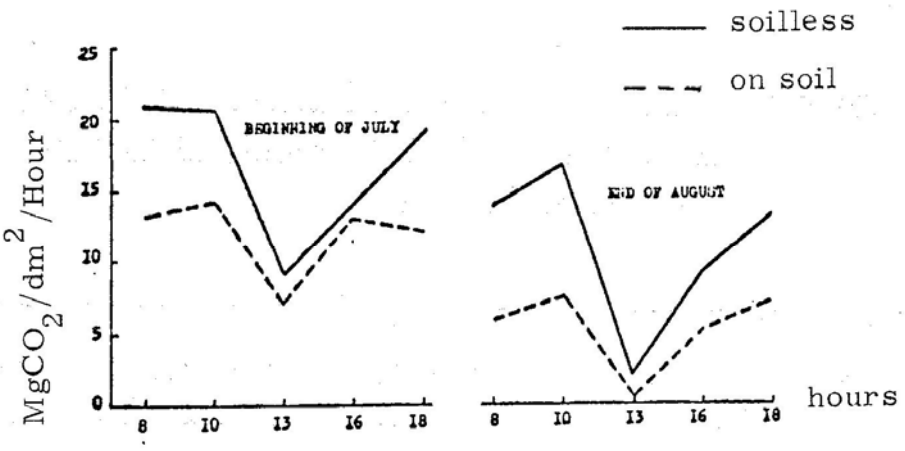

Fig. 1 - Changes of the intensivity of photosynthesis in tobacco leaves during the day. (Average data from 12-16 series of observations in three years).

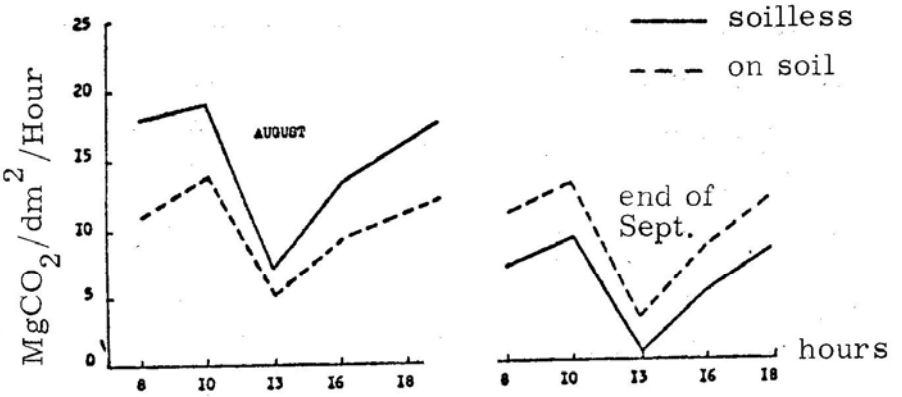

Fig. 2 - Changes of the intensivity of photosynthesis in the Rosy geranium during the day. (Average data from 12-14 series of determination in three years).

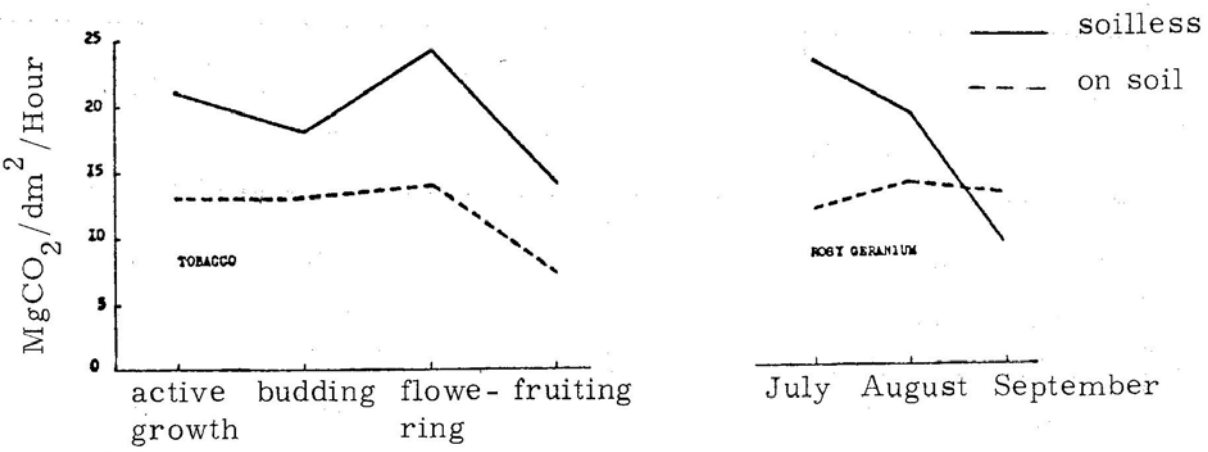

Fig. 3 - Changes of the intensivity of photosynthesis during the vegetation period at 10 o'clock. (Average data from 12-16 series of observations in three years).

Table 1 - Yield of dry matter* of plants grown under conditions of the Ararat plain. (Average, in tons per hectare)

Culture	On Soil	Soilless	Ratio
Carrot, root-crops	2 - 2.5	7 - 9	3.5
carrot tops	1	5 - 6	5.5
total	3 - 3.5	12 - 15	4.2
Sugar-beet, root-crops	8	23	2.9
beet tops	5	16	3.2
total	13	39	3.0
Tomatoes, fruit yield	2,	5 - 7	3.0
stalks & leaves	1	1 - 2	1.5
total	3	6 - 9	2.5
Rosy Geranium, green mass.	4	11 - 18	3.6
Essential oil.	0.02	0.06 - 0.1	4.0
Nightshade, green ass	1.3	13	7.2
solasodin.	0.03	0.22	7.3
Tobacco, leaves	1 - 2	5 - 6	3.7
Capsicum, pods	1 - 2	5 - 6	3.7
2asil„ green mass	2 - 4	11 - 14	4.2
Parsley,	2 - 3	14 - 18	6•4
Celery,	2 - 3	23 - 24	9.4
Coriandro,	2	8 - 9	4.3

Calculated on various (factual) indices in % of dry matter on soil and under hydroponics. Results are rounded. Observations from 1962-1974.

The most important of these factors is the practically uninterrupted and simultaneous suppy of water, air, and nutrient elements to the roots of plants. The greatly favourable intensification of root nutrition activates the physiological functions of the over-ground organs of the plants. And this communication of ours is devoted to the examples of the considerably high increase of intensivity of the most important of those functions - to the photosynthesis of the tobacco and rosy geranium plants. Putting aside the details, we bring forth only the summarized average data from 12 to 16 series of determinations in the last three years (1972 to 1974) carried out by our co-worker B. Mezhunts (Pic. 1, 2, 3).

A significant intensification of photosynthesis under out-door hydroponic conditions (as well as under hot-house hydroponics) has been observed by us on many other plants too.

Thus, thanks to the intensification of mineral nutrition with the simultaneous improvement of the water-air regime of the root system of plants under hydroponic conditions, the intensivity of photosynthesis, as a rule, increases considerably, the utilization coefficient of solar energy increases many times, while the Productivity of plants rises from 3 to 7 times and even more.

X

XI - MOLECULAR BASIS OF PHOTOMORPHOGENESIS

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The photoautotropic higher plant is optimized with respect to the light factor. This ,optimization becomes manifest in photosynthesis, development, "behavior" and reproduction. The process of optimization is naturally controlled by endogenous factors. We call this aspect developmental homoeostasis. However, the external factor "light" also plays a decisive role in controlling the optimization of a developing plant with regard to the light factor (Fig.1). This is obviously a kind of "positive feedback". The developing higher plant is thus a useful model system to consider the relationship between endogenous and exogenous control of development. For this reason, higher plants play a major role in developmental genetics [2].

We have studied over the years the development of the cotyledons of the mustard seedling, Sinapis alba (Fig.2). These cotyledons are peculiar organs. As long as the seedling develops in the dark exclusively, the cotyledons function as storage organs. Filled with storage fat and storage protein, they serve the requirements of the rapidly-growing axis system. The cotyledons themselves do not grow or develop significantly as long as the seedling is kept in complete darkness. However, when the seedling is illuminated with white light of significantly high irradiance, the cotyledons are transformed rapidly into photosynthetic organs, very similar in internal structure and in function to a normal photosynthetically active leaf. The "mechanism" of the phototransformation of the cotyledons has been studied in an effort to understand, on the molecular level, the developmental events leading to the phenomenon of photomorphogenesis. By the term "photomorphogenesis" we designate the normal development of the sporophyte of a higher plant. Without the light factor, this normal development cannot occur. Rather, the plant will etiolate until it dies (see Fig.1, 2). Thus, when we study the molecular basis of photomorphogenesis, we study in fact the molecular basis of normal development in higher plants.

We may assume that the development of the cotyledons under the influence of light represents the corresponding events in young leaves. However, since the cotyledons contain a non-limiting supply of storage molecules, the molecular events leading to a functional leaf, including the functional photosynthetic apparatus, can be studied much more precisely in these organs than, e.g., in primary leaves which have preferentially been used in the pant.

THE PHYTOCHROME SYSTEM

Photomorphogenesis in the mustard seedling is mediated through phytochrome. There are no data which suggest the involvement of other pigments. Phytochrome, a chromoprotein, is a photochromic sensor pigment O. Phytochrome is the post important molecule in higher plants for the etection of photosignals from the environment and for making use of this information to optimize development, behavior and reproduction of the plant. In the following, we use the phytochrome model as given in Fig. 3. This model describes quantitatively the properties of the phytochrome system as it occurs in the cotyledons and in the hypocotylar hook of the mustard seedling during the period of our experimentation. The P_{fr} form of the chromoprotein is the physiologically active form, the effector molecule. P_r has no physiological effect. The sum of the amounts of P_R and $\mathbf{Pf_r}$ is called "total phytochrome", or P_{total}. In a dark-grown seedling, only P_r is present. De novo synthesis of Pr is a zero order process which does not depend on light. The physiologically active P_f originates from P_r through a first order phototransformation which is photoreversible. Pfr is not stable. It disappears through a first order destruction process which is independent of light. The half-life of Pfr in the mustard cotyledons is 45 min at 25° C.

An important property of the phytochrome system is that it develops a steady state under continuous light. On the basis of the present model, any change of total phytochrome can be described by the equation

$$\frac{dP}{dt} = k_0 + k_1 \cdot \ldots$$

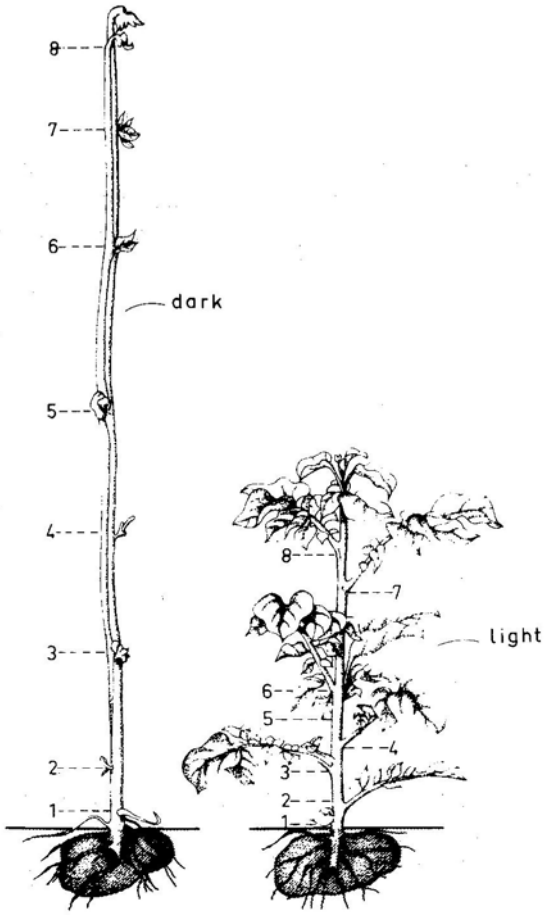

Fig. 1

These two potato plants (Solanurn tuberosum) are genetically identical, Nevertheless, the dark-grown and the light-grown plants differ greatly. Whereas in the light the normal potato plant will develop, the sprouts will "etiolate" in darkness (after [11).

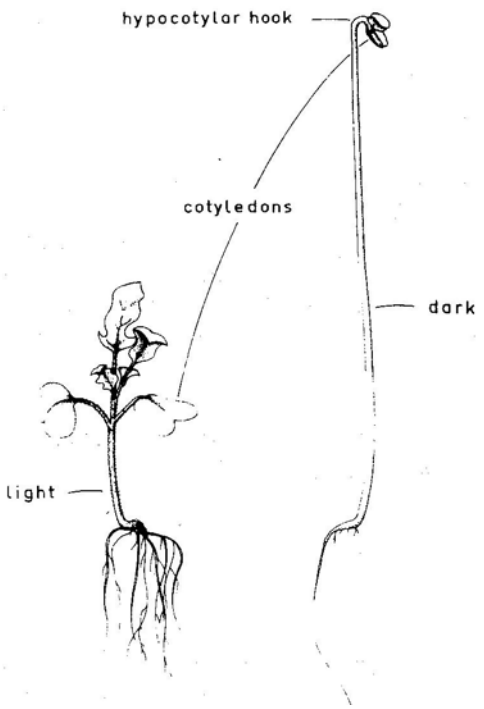

Fig. 2

These two mustard seedlings (Sinapis alba) have the same chronological age and are virtually identical genetically. The differences in morphogenesis are due to light. The drawings emphasize the point that light causes the cotyledons to develop from storage organs (right) to photosynthetically active leaves (left). Unlike, for instance, castor bean endosperm, the mustard cotyledon is not devoid of function after depletion of lipid and protein reserves, since in the light it expands, becomes green and persists as a photosynthetic organ (after [11).

which means that a differential change of total phytochrome is equal to the difference of the rates of P_r synthesis and $_{Pfr}$ destruction. Under steady state conditions as defined by "no change of Ptotal" the rate of P_r synthesis is equal to the rate of Pfr destruction,

$$\text{or,} \quad \frac{d[P_{tot}]}{dt} = 0, \text{ by definition.}$$

$$\text{Therefore } o_{k_s} = 1_{k_d} \quad [P_{fr}] \quad \text{or}$$

$$\frac{o_{k_s}}{o_{k_d}} = [P_{fr}]$$

In other words, the steady state concentration of the effector molecule Pis only a function of the rate constants for P_r synthesis and Pfr destruction which are both light independent. This means that the steady state concentration of the effector molecule Pf_r does not depend on the wavelength of the light incident on the system. The only prerequisite is that the incident light is absorbed by both phytochrome forms to an extent sufficient to establish a steady state.

This property of the phytochrome system offers the opportunity to run the steady state of the phytochrome system at a wavelength which does not cause significant chlorophyll synthesis or photosynthesis. We have been using over the years a standard far-red light source which is equivalent, as far as the phytochrome system is concerned, to the wavelength 718 nm. When we irradiate a mustard seedling grown under rigorously standardized conditions in the dark at 25° C at 36 h after sowing,the photo steady state of the phytochrome System in the mustarg cotyledons will rapidly be established and maintained over many hours [5].

This has been a brief sketch of the phytochrome system as it occurs in the mustard seedling cotyledons attached to the intact plant.

CONTROL OF ENZYME LEVELS BY PHTrOCHRONE

We assume that development is primarily the consequence of an orderly sequence of changes in the enzyme complement of an organism. Therefore, the investigator of photomorphogenesis will primarily try to explore thocc phytcchrome-mediated responses in which changes in enzyme levels have a well-defined causal role in well-defined developmental steps. We have been engaged over the years in a number of studies on phytochrome-mediated enzyme induction and enzyme repression in the attached mustard seedling cotyledons. The principal results of these studies can be summarized as follows (Fig. 4): The active phytochrome, P_{fr}, in the mustard cotyledons can rapidly mediate enzyme induction as well as enzyme repression. The symbol delat E3/delta T remains

$$P_r' \xrightarrow{{}^{o}k_s} P_r \underset{k_2}{\overset{k_1}{\rightleftharpoons}} P_{fr} \xrightarrow{k_d} P_{fr}'$$

Fig. 3 - A model of the phytochrome system as it occurs in mustard seedling cotyledons and hypocotylar hook.

$P_r' \xrightarrow{{}^{o}k_s} P_r$ represents de novo synthesis ; $P_r \underset{{}^{1}k_2}{\overset{{}^{1}k_1}{\rightleftharpoons}} P_{fr}$ represents the light reactions ; $P_{fr} \xrightarrow{{}^{1}k_d} P_{fr}'$ represents the dark destruction (after [4]).

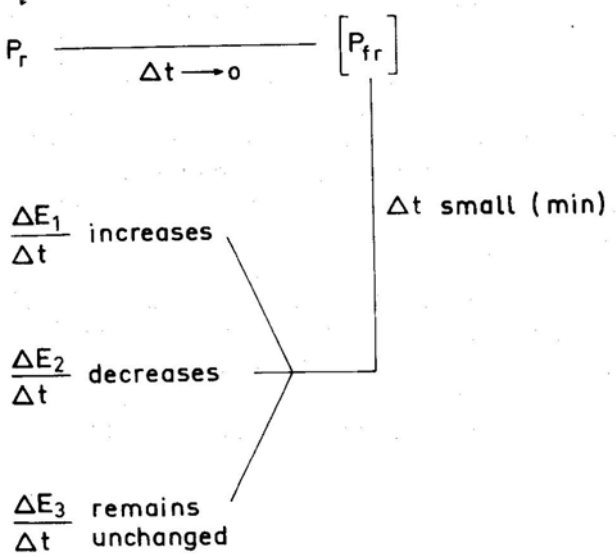

Fig. 4

This scheme illustrates the concept that the effector molecule P_{fr} in one and the same organ or tissue can rapidly mediate enzyme induction (above) as well as enzyme repression (middle) (after [1]).

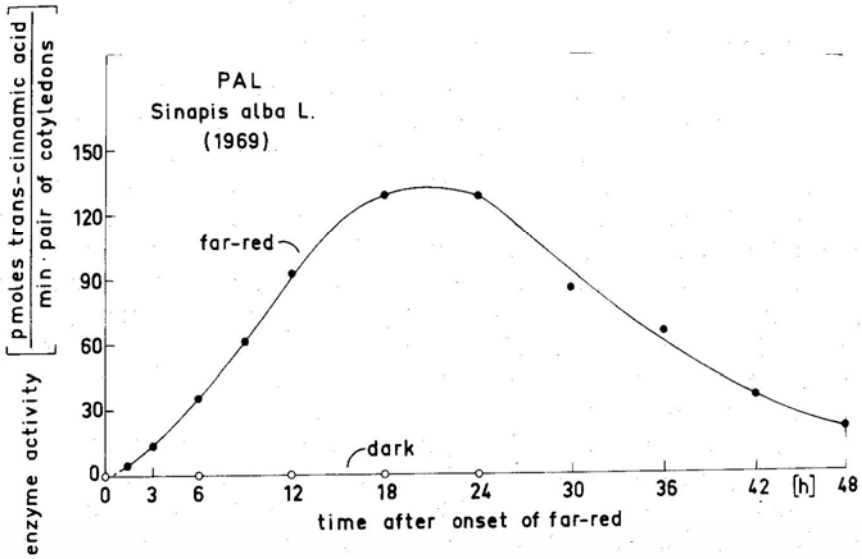

Fig. 5 - The influence of continuous far-red light on the time-course of the enzyme PAL (phenylalanine ammonia-lyase) in the cotyledons of the mustard seedling. Onset of far-red light : 36 h after sowing. In the dark-grown mustard cotyledons PAL activity cannot be detected by the assay which was used in this investigation (after [6]).

unchanged" designates that some enzyme levels will not respond to the presence or absence of $Pf_{.r.}$ With regard to terminology, I would like to emphasize that originally the terms "induction" and "repression" were used Operationally in molecular biology to designate the appearance or lack of appearance of an enzyme. We have continued using the terms "induction" and "repression" as originally defined, i.e. without a priori imlications about the actual control mechanism. Thus "enzyme induction by photochrome" means an increase of enzyme level caused by photochrome, whereas "enzyme repression by photochrome" means that an increase of enzyme level is arrested by photochrome.

In the present talk, I will largely ignore the abundant but already classical phenomenology of phytochrome-mediated enzyme induction and enzyme repression (see [1]). I will only repeat the principal findings. Figure 5 shows a typical example of enzyme induction by Pf_r in the case of a relatively short-lived enzyme, phenylalanine ammonia-lyase, abbreviated PAL. Figure 6 shows an example of the repression of a long-lived enzyme, lipoxygenase, abbreviated LOG, and Figure 7 shows an example of those enzymes in the mustard seedling cotyledons whose time course of extractable activity is not changed by photochrome at all.

In what follows, I want to concentrate on some recent studies which contribute to our knowledge about the mechanism of phytockrome control of enzyme levels. For reasons of time, I will ignore the structural aspects altogether, although they have attracted our interest during recent years, in particular with respect to phytochrome-mediated development of plastids and microbodies [9, 10].

BASAL ENZYME LEVEL VS. INDUCED ENZYME LEVEL

A basic question in the present discussion about the nechanisme of photochrome-mediated enzyme induction has been whether or not the phytochrome-mediated induction is simply a quantitative modulation, i.e. an increase over the low basal level, rather than the appearance of enzyme activity which was totally absent in the dark. The latter alternative means that the appearance of an enzyme in the dark-grown tissue (in our present case in the cotyledons of the mustard seedling) and the phytochrome-mediated app pearance of the enzyme are unrelated phenomena, occuring in different cells or tissues. Since any model of the mechanism of phytochrome-mediated enzyme induction depends essentially on our knowledge of the relationship beta n the basal enzyme level and the light-mediated enzyme level, we have tried several approchaes to solve this problem. For reasons of time, I will only consider briefly the enzyme phenylalanine ammonia-lyase (PAL), an enzym which is characterized by a very low basal level and considerable turnover (Fig. 8). Density labelling with deuterium provides evidence that the low basel level in the dark is due to rapid synthesis and corresponding rapid degradation of the enzyme, and that any increase of the PAL level is connected with de novo synthesis of the enzyme protein [11, 12]. We have been concerned with the question of how the far-red light mediated kinetics of the PAL levels in the mustard cotyledons can be understood. The elaboration of light to dark kinetics has provided a partial answer to this question. The basis of these experiments (as far as the phytochrome system

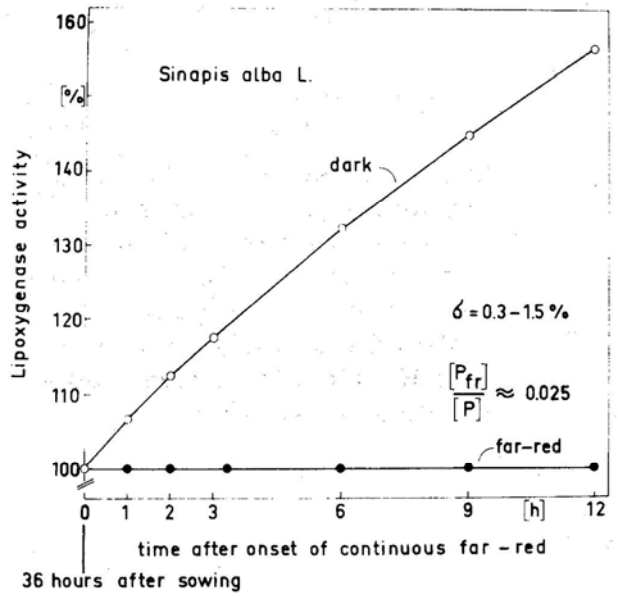

Fig. 6

The increase of the enzyme LOG (lipoxygenase) in the dark-grown mustard seedling cotyledons is arrested by continuous standard far-red light. The available information indicates that LOG is a stable enzyme during the period of experimentation. A lag-phase of the repression response is not detectable (after [7]).

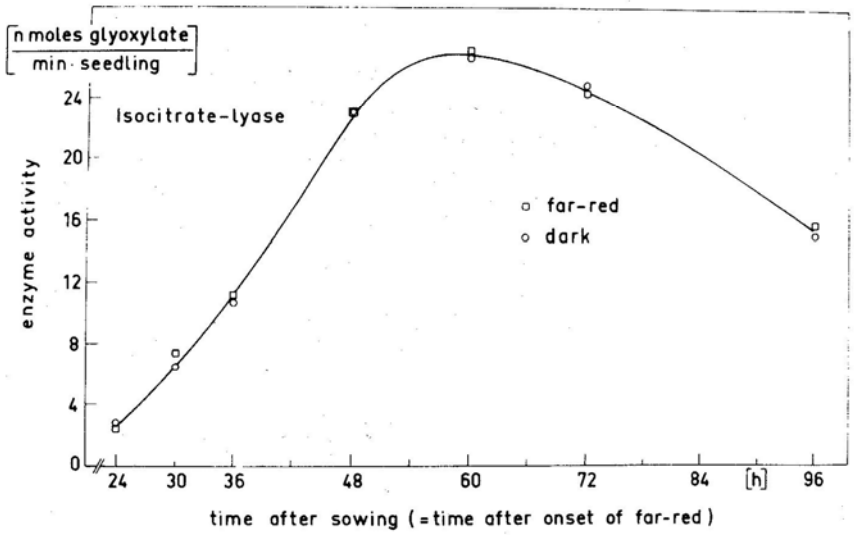

Fig. 7

Time-course of isocitrate-lyase in the mustard seedling in darkness and under the influence of continuous far-red light (after [8]).

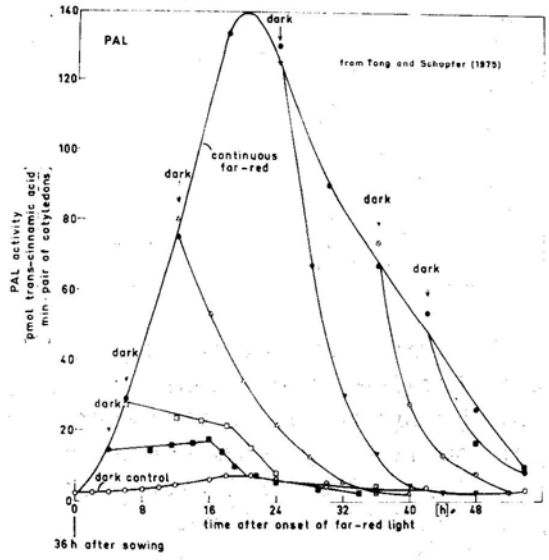

Fig. 8 - Kinetics (time-courses) of the enzyme PAL in the cotyledons of the mustard seedling in the dark and under the influence of continuous standard far-red light. Onset of light : 36 h after sowing. In addition, a number of far-red → dark kinetics are indicated. This term is used to designate those kinetics of the enzyme which are observed after the standard far-red light has been turned off and followed by 5 mn 756 nm light (at arrows). The postirradiation with 756 nm light reverts almost all P_{fr} back to P_r. Thus, the cotyledons are virtually free from the effector molecule P_{fr} at the beginning of the dark period (after [10]).

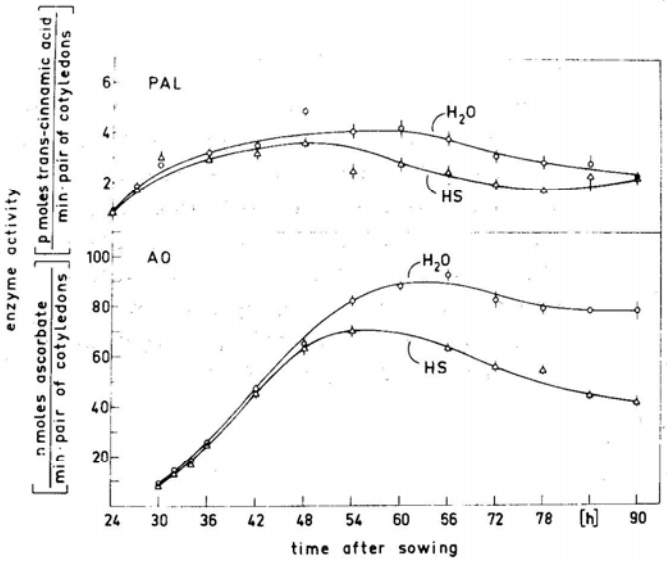

Fig. 9

Time-courses of phenylalanine ammonia-lyase (PAL) and ascorbate oxidase (AO) levels in the mustard seedling cotyledons in the dark supplied with distilled water (H_2O, -O-) or with Hoagland's nutrient solution (HS, -△-) (after [13]).

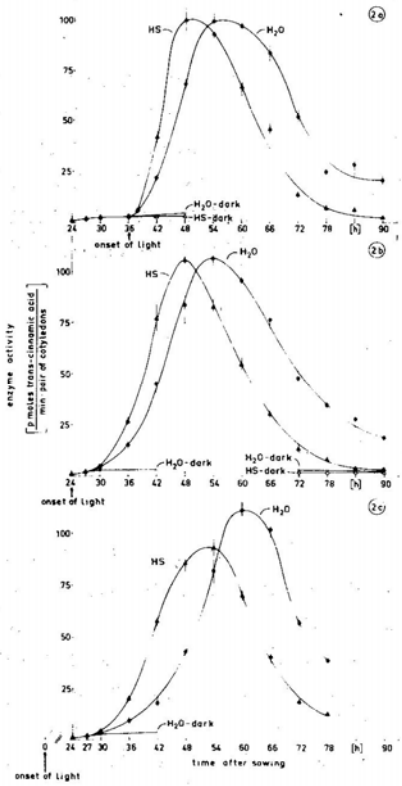

Fig. 10 - Time-courses of PAL levels in the cotyledons of the mustard seedling under continuous far-red light. The seedlings were supplied with distilled water (H_2O, -●-) or with Hoagland's nutrient solution (HS, -▲-). 2a : onset of light at 36 h after sowing ; 2b : onset of light at 24 h after sowing ; 2c : onset of light at time zero (sowing) (after [13]).

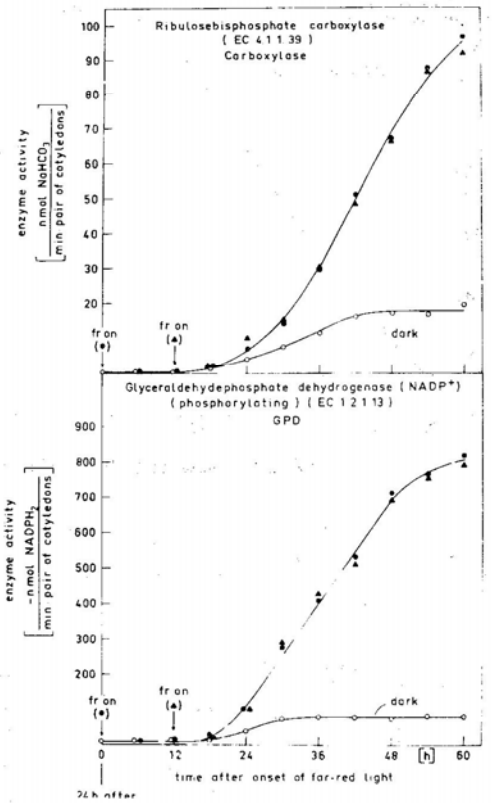

Fig. 11 - Time-courses of the levels of carboxylase and GPD in the cotyledons of the mustard seedling in the dark and under continuous far-red light. Onset of far-red light (fr) at 24 or 36 h after sowing (after [14]).

is concerned) is briefly the following: At the moment when the far-red light is turned off and followed by a 5 min pulse with 756 nm light, nearly all Pfr, molecules are eliminated from the system. Against this background, Fig. 8 shows that Pfr is continuously required in order to maintain an increase of the PAL level. Further, the light to dark kinetics indicate that, with respect to the light-mediated enzyme, a degradation comes into play only slowly, approximately 6 h after the onset of light. And thirdly: the decrease of the PAL level after 20 h is due to a decrease , of enzyme synthesis rather than to a change of the rate of enzyme degradation.

The data in Fig. 8 suggest that the regulation of the PAL level in the mustard cotyledons is complex and that the "dark PAL" and the "light-mediated PAL" belong to different pools which are not related to each other.

This conclusion was checked using a completely different approach. We have made *use* of a second external factor in addition to light, namely a combination of inorganic ions, known as Hoagland's solution. Hoagland's solution was applied to the mustard seedlings instead of distilled water at the time of sowing. It was observed that in the dark, Hoagland's solution (HS) stimulates enzyme disappearance (Fig. 9). There is no positive effect of HS on the appearance of PAL in the dark. On the other hand, however, HS exerts specific effects on the appearance of the enzyme in the light; there is a strong stimulation of the rate of enzyme appearance (Fig. 10). However, the onset of the light-mediated activity increase remains prec.. isely at 29 h after sowing irrespective of light treatment. Note that in the dark, a detectable increase of the PAL level occurs at 24 h, that is, at least 5 h earlier! The data suggest that HS specifically affects phytochrome-mediated PAL synthesis, whereas appearance of the same enzyme in the dark is not affected. It is concluded that the appearance of PAL in the dark and phytochrome-mediated appearance are independent phenomena and that the mechanism of PAL induction by photochrome can be studied without considering the mechanism leading to the basal level in the dark.

PHYTOCHROME ACTION AND DEVELOPMITAL HOMEOSTASIS

We deal with this topic by looking at two characteristic marker enzymes of the plastid compartment, namely ribulose-bisphosphate-carboxylase, abbreviated "carboxylase" and NADP-dependent glyceraldshydephosphate-dehydrogenase, abbreviated "GPD". These are two important enzymes of the Calvin cycle which is a biochemical sequence locatted in the matrix of the plastid compartment serving the fixation and reduction of CO_2. In contrast to PAL, these enzymes are stable during the experimental period, i.e. significant turnover must not be considered. In the dark grown mustard seedling, the level of carboxylase and GPD in the cotyledons remains low; however, both enzymes can be "induced" by phytochrone, operationally by continuous far-red light (Fig. 11). The young mustard seedling'does not contain carboxylase, nor GPD. Both enzymes can only be measured 42 h after sowing. And now the important point in our present context.

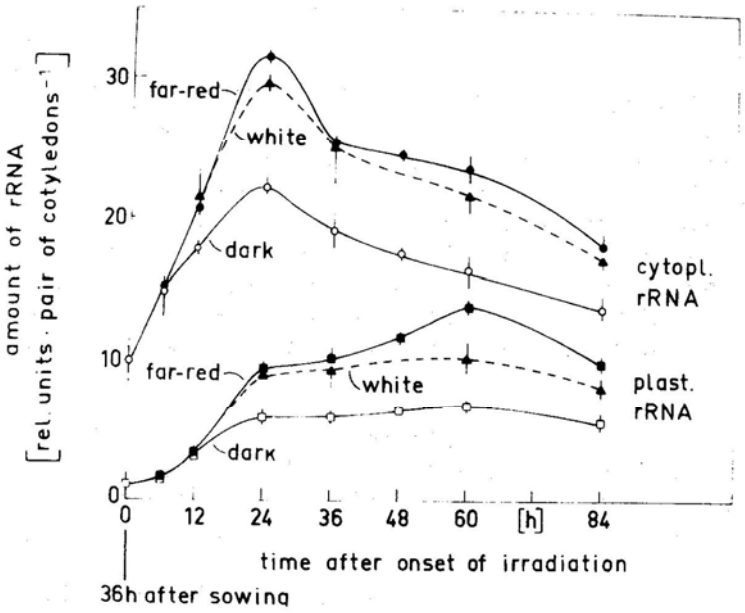

Fig. 12

Time-courses of the levels of cytoplasmic and plastid rRNA in the cotyledons of 36-h-old mustard seedlings kept in darkness (O) or irradiated with continuous far-red (●) or white (▲) light (cytopl. rRNA : 1.3×10^6 plus 0.7×10^6 mol wt RNA ; plast. rRNA : 1.1×10^6 plus 0.56×10^6 mol wt RNA) (after [16]).

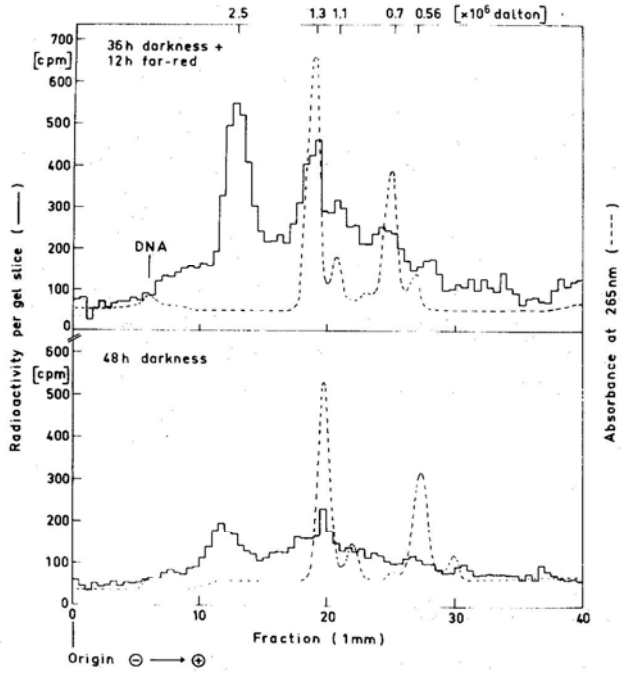

Fig. 13

Stimulation of precursor-rRNA labelling by a pre-irradiation with far-red light in the cotyledons of 48-h-old mustard (Sinapis alba) seedlings. Seedlings were grown aseptically in darkness for 36 h and subsequently irradiated for 12 h with standard far-red light (3.5 W. m^{-2}) or kept in darkness. Cotyledons of 40 seedlings were isolated and incubated for 15 min with 2 ml distilled water containing 200 Ci 28 000 mCi/mmol [5-^{3}H]uridine in a 5-cm diameter petri dish on a shaker. Manipulations and incubation were performed under far-red light in the case of pre-irradiated seedlings and under a weak green safelight in the case of dark-grown seedlings. After the labelling period the cotyledons were frozen in liquid N_2 and nucleic acids extracted and subjected to 2.4 % polyacrylamide gel electrophoresis. The gels were scanned for UV absorbance and sectioned in 1 mm slices, the radioactivity of which was measured by liquid scintillation counting (toluene cocktail) after solubilization of the gel. Total uptake of label was assayed by measuring the radioactivity of the tissue homogenate obtained from cotyledons which were washed for 5 min with ice cold water to remove the uridine from the cell wall space after the incubation. Uptake of label into the cotyledons was not significantly influenced by the light treatment (after [15]).

For the induction of the Calvin cycle enzymes, it does not matter whether Pfr is functioning in the seedling from 24 h after sowing or only from 36 h after sowing onwards. This observation indicates the action of endogenous regulatory factors which determine the time course of what we call primary differentiation or acquisition of competence. We do not know the nature of these factors - and neither do our colleagues in hormone physiology - and we cannot handle them experimentally. In any case, these endogenous factors which manifest themselves in the developmental hoemeostatis of seedlings development do not depend on light. In the case of carboxylase and GPD, these factors prevent enzyme induction by phytochrome before 42 h after sowing irrespective of light treatment. Other enzymes in the mustard cotyledons, not related to photosynthesis, can be induced by phytochrome much earlier in the course of development. As an example, we have just mentioned (Fig. 10) that the key enzyme of flavonoid biosynthesis, phenylalanine-ammonia-lyase, becomes inducible by Pfr at 29 h after sowing.

At first sight, the time courses of the two Calvin cycle enzymes look very similar. More detailed studies have shown, however, that a simultaneous and coordinated induction in a strict mechanistic sense may not be assumed. Rather, we had to conclude that both enzymes are "induced" by Pf_r independently of each other [14). Unfortunately, I have no time to support this statement by experimental evidence.

PHYTOCHROME-MEDIATED CHANGES ON THE RP A LEVEL

So far the molecular analysis has only successful in the case of ribosomal RNA [15, 16]. Phytochrome, operationally "continuous far-red light" stimula es the accumulation of cytoplasmic and plastid rPNA in the cotyledons cf the mustard seedling as shown by Thien and Schopfer (Fig. 12). In 36 h old seedlings placed under continuous far-red light, the cytoplasmic and plastid rRNA species will increase after a lag phase of more than 6 h and reach a maximum level about 24-36 h later. These date have been interpreted in terms of a phytochrome-mediated stimulation of the nuclear and pastid rDNA transcription rate. Figure 13 gives evidence in support of this conclusion. Thien and Schopfer have performed short-term labelling, experiments on the level of the high molecular weight precursor rRNA (pre-rRNA) which is a direct product of rDNA transcription also in plants. After a 15 min pulse with ^{3}H-uridine, the label located in the pre-rRNA region of the polyacrylamide gel is considerably increased if the seedlings have been irradiated with far-red light for 12 h prior to labelling. At the termination of the pulse, a small part of the radioactivity has already reached the 1.3×10^6 and 0.7×10^6 dalton split products, indication a rapid turnover of the pre-rRNA. Longer labelling periods lead to a strong increase in radioactivity of the 1.3 N $\times 10^6$ and 0.7×10^6 dalton rRNA peaks and to an equilization of labelling in the pre-rRNA peaks obtained from dark-grown and far-red treated seedlings. This kind of data supports the conclusion that phytochrome is able to strongly activate the transcription of rRNA cistrons and the processing of the precursor rRNA.

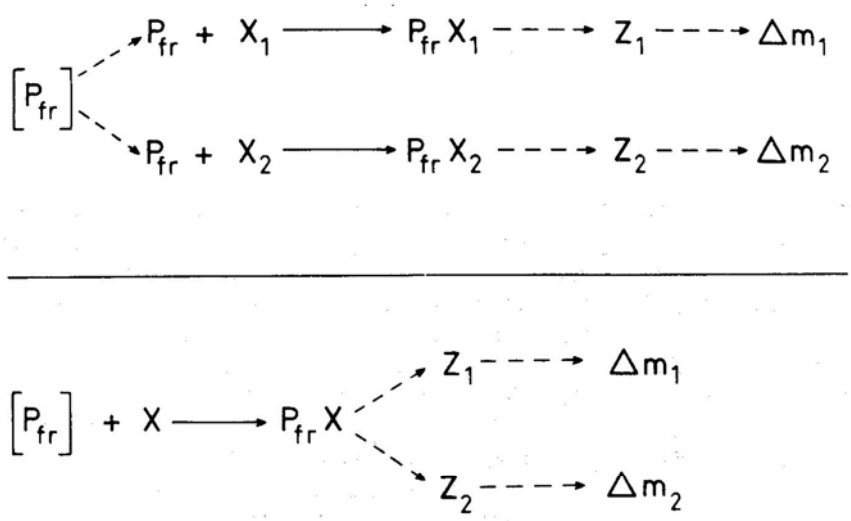

Fig. 14 - Two alternative models of the primary reaction of P_{fr}. x : primary reactant (s) of P_{fr} ; Δm, extent of P_{fr}-mediated responses ; z : intermediates between $P_{fr}x$ and the responses (for details refer to [1]).

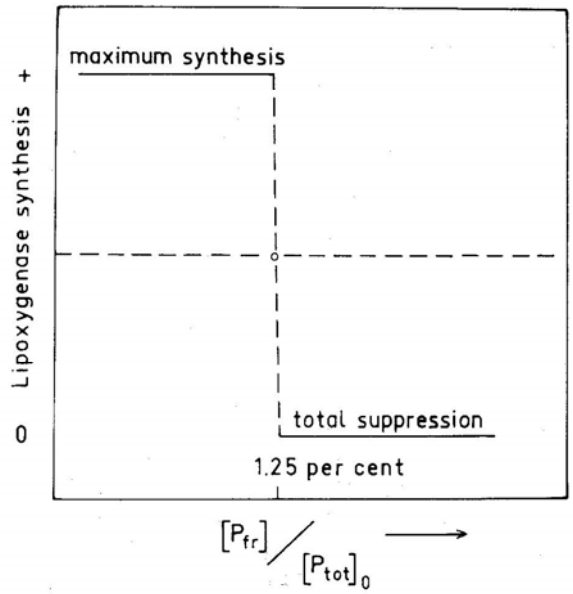

Fig. 15 - A scheme to describe the concept of a threshold regulation of lipoxygenase synthesis in the mustard seedling cotyledons by P_{fr}. $[P_{tot}]_o$ is the total phytochrome at time zero (36 h after sowing). This value is a constant. The amount of P_{fr}, $[P_{fr}]$, is always expressed as a fraction or percentage of $[P_{tot}]_o$. Expressed in this way the threshold level, $[P_{fr}]_{th}$, is approximately 1.25 percent (0.0125) (after [18]).

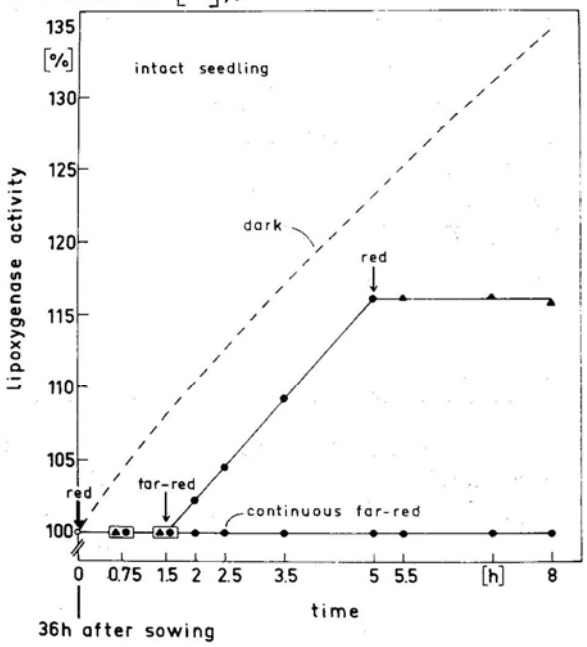

Fig. 16 - Time-courses of lipoxygenase levels in the mustard seedling cotyledons in darkness (---), under continuous far-red light (●) and under the irradiation sequence 1.5 h red light (▲) - 3.5 h far-red light (●) - 3 h red light (▲). While red light establishes a P_{fr} level above the threshold level under all circumstances, far-red light (given after 1.5 h red light) establishes a P_{fr} level below the threshold level. Far-red light without the red light pretreatment establishes a P_{fr} level above the threshold level (after [19]).

THE PRIMARY REACTION OF PHYTOOBROME

This has. been a very serious problem over the years. The alternatives are clear (Fig. 14): does the huge multiplicity of different photoresponses or displays indicated by the symbol Am originate from a single primary reaction, in other words is there only one single primary reactant X for $_{Pfr,}$ at least in a given plant? ¯Or: is there a plurality of primary reactions due to a plurality of 'primary reactants? In this latter case, which is illustrated on the upper part of Figure 14, one can uphold the concept that X is always the same substance but may be embedded as an integral constituent in structually and functionally different matrices. In our opinion, the experimental data are only consistent with this second alternative, namely that there are several primary reactions of Pfr which differ in principle, e.g. with respect to cooperativity of the Pfr + X conversion to Pfr X reaction.

Figure 15 summarizes a major result of our 6 years work on control. of liEoxygenase synthesis by phytochrome in the mustard seedling cotyledons pd. Lipoxygenase (LOG) synthesis is controlled by P_{fr} through a threshold (all-or-none) mechanism. If the amount of P_{fr} exceeds the threshold level, LOG synthesis is fully and immediately arrested. If the amount of P_{fr} decreases below the threshold level, LOG synthesis is immediately resumed at full speed. This pattern of response is illustrated in Figure 16: LOG increases in the dark; synthesis of the enzyme is suppressed by Pr_r above the threshold level (red at time zero). As soon as the Pfr level decreasesbelow the threshold level (far-red at 1.5 h), LOG synthesis is resumed at full speed; as soon as the P_{fr} level increases above the threshold level (red at 5 h), LOG synthesis is again arrested, immediately and totally.

It was concluded that in the case of threshold regulation, the primary reaction of P. is characterized by a high degree of cooperativity 031. The cooperative step is located between $P_{fr}X$ and P„X' whereby X is the primary reactant, or primary receptor of Pi and " X' is a somewhat changed primary reactant. $_{PfrX'}$ is the physi**ologically** active complex. Figure 17 describes the properties of the cooperative step with regard to LOG synthesis. Appropriate models based on ligend-matric-interactions have been elaborated and supported experimentally C27]. However, this matter is too complicated to be dealt with in an introductory lecture. The "primary reaction of $_{Pfr"}$ in the case of the LOG response must be written as

P + X conversion to Pfr X conversion to Pfr X’

The reversible threshold reaction is thus an integral part of the "primary reaction" occuring at the "matrix" specific for the LOG response. This statement "matrix specific for the LOG response" points at-the major problem. Namely, this term implies, that only a fraction of total phytochrome is involved in the control of LOG synthesis. It further implies that only a fraction of total Preacts with the Pfr -receptors at that particular matrix which is connected to LOG synthesis.

$P_{fr}X \rightleftharpoons P_{fr}X'$

stable at $[P_{fr}] < 1.25$ per cent	stable at $[P_{fr}] > 1.25$ per cent
no P_{fr} destruction	P_{fr} destruction (^1k_d)
LOG „synthesis" unimpaired	LOG „synthesis" suppressed

Fig. 17 - The simplest formulation of the actual threshold reaction in the lipoxygenase response [20]. The element X' is taken from the open phytochrome-receptor-model advanced by Schäfer [21]. It was suggested that the receptor X to which phytochrome rapidly binds exists in two forms (X and X') and that the transition X ⟶ X' is mediated by P_{fr} above the threshold.

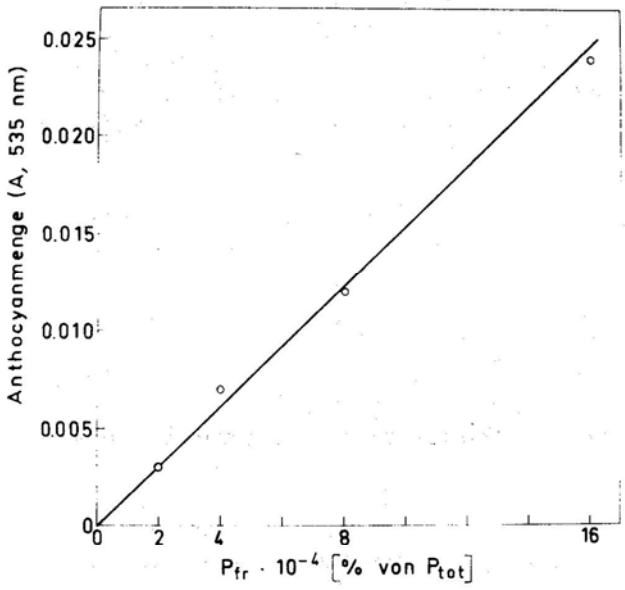

Fig. 18

The dose $[P_{fr}]$ response curve in phytochrome-mediated anthocyanin synthesis in the mustard seedling in the neighbourhood of point zero. The curve is linear and extrapolates through zero (after [22]).

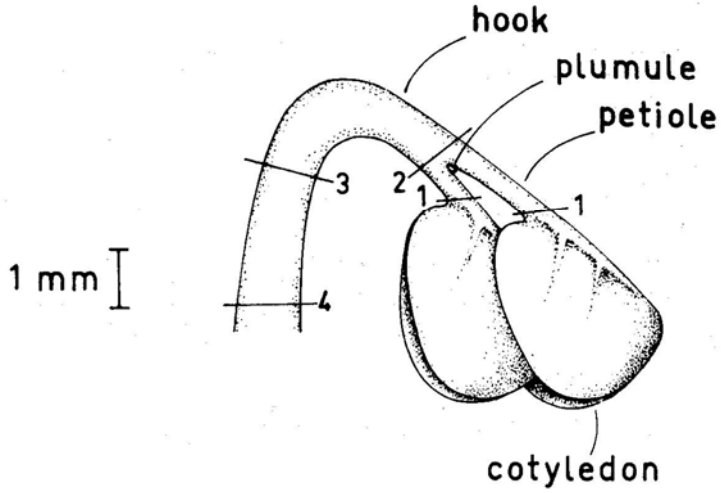

Fig. 19 - The upper parts of the mustard seedling 36 h after sowing (after [19]). With isolated cotyledons, no suppression by light of lipoxygenase synthesis can be detected. As soon as the cotyledons are separated from the hook, the control of lipoxygenase synthesis by P_{fr} is completely lost. It was concluded [19, 23] that lipoxygenase synthesis in the cotyledons is controlled by phytochrome located in the hypocotylar hook.

The basic question we further follow has been whether or not the primary reaction of P_f always obeys the characteristics of a threshold reaction. This is not Ehe case. As an example, we have shown that in another well-investigated response, namely in the case of phytochrome-mediated anthocyanin synthesis in the mustard seedling, no threshold reaction is involved [22].

Figure 18 shows the P_{f_r}-response curve in the neighbourhood of point zero for phytochrome-mediated anthocyanin synthesis in the mustard seedling cotyledons. It is obvious that the dose-response curve extrapolates through zero and is linear over a considerable range. In terms of the phytochrome receptor model (Figure **17),** with respect to phytochrome-mediated anthocyanin synthesis, there is no threshold for the transition of PfrX to Pfr X'. The signal transfer at this point is perfectly linear.

We think that there is no escape from the conclusion that P_{fr}-mediated control of anthocyanin synthesis in the mustard seedling (no threshold, no cooperativity) and P_f -mediatedcontrol of LOG synthesis differ in principle even at the level of the "primary reaction". The conclusion was drawn [20, 22] that there must exist within a plant a plurality or even multiplicity of response-specific "mstrices" to which P can bind. As already pointed cut, the element X is possible *always* ge same but at least the matrices of which X is an integral constituent must differ greatly.

TO SUMMARIZE

Phytochrome-mediated photomorphogenesis is obviously related to differential gene expression. This can clearly be shown on the enzyme level. Phytochrome acts by permitting the development of a pre-existing pattern of primary differentiation. The development of this pattern is not influenced by phytochrome. The tacitly assumed premise in much of the phytochrome work that there is *a* single primary reaction is not justified. Instead, a plurality of reactions in which phytochrome directly participates must be envisaged.

INTERORGAN CORRELATION IN THE MUSTARD SEEDLING

At the end of my talk, I would like to **mention** briefly a second fascinating feature of the lipoxygenase response, namely that the effector molecule Pfr, which exerts the threshold control over lipoxygenase synthesis, is very probably located in the hypocotylar hook, whereas lipoxygenase synthesis takes place in the cotyledons (Fig. 19). Thus a signal transfer between neighbouring organs is involved in this response. It was shown experimentally that the signal transfer from the hypocotylar hook to the cotyledons is rapid and precise and that the signal cannot be stored in the cotyledons n. The signal transfer cannot be accounted for by hormones. Some biophysical signal must be involved. We believe that the morphological basis for the rapid and extremely accurate signal transfer is the intercellular connections known as plasmodesmata.

The suppression of lipoxygenase synthesis is - to my knowledge - the most precise, cooperative reaction so far observed in plants. The hypocotylar hook has amazing properties as a receptor and as a processing organ for light signals from the environment.

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XII - THERMOSTABILITY OF CELLS AND TEMPERATURE CONDITIONS OF SPECIES LIFE

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A correlationship between the resistance of cells to the action of high temperature and temperature conditions of a species existence no doubt reflects an important biological regularity. This is evidenced by the fact that this phenomenon has been observed practically in all groups of living organisms, from all climatic zones.

We have evaluated cellular thermostability in more than 500 species, mainly in flowering plants. The heat stability was estimated by the reaction of various cellular functions to short-term (5 to 40 min) heat treatments. The injury produced was assessed immediately after the end of a heat exposure. It is our contention, that such an approach allowed for determining the primary thermostability of cells, which is referable to the resistance of protoplasmic proteins.

The level of cellular thermostability depends, among other things, also on the taxonomic position of plants. It is determined by pecularities of the structure and metabolism, characteristic of entire genera and, presumably, of families too. Therefore, the regularity we are interested in is most distinctly revealed when comparing fairly related taxa differing in their thermophily.

Our primary ccncern was to compare the species belonging to one genus. We have studied over 160 species from approximately 50 genera. In the overwhelming majority of cases, a comparison of species which differ reliably in their thermophily, indicated a corresponding difference in thermostability of their leaf cells. Different heat resistance has been found for various leaf cell and tissue functions. Thus, different thermostability has been detected in cells of plant species from similar areas, but characteristic of different vegetation periods. Fig.1 shows the thermostability of the protoplasmic streaming in leaf cells of 18 species of Allium genus from Central Asia. It can be seen that in the cells of ephemeroids, the streaming stops after milder heatings than in species vegetating over the whole summer. It has been found also that respiration and capacity for plasmolysis were less resistant in ephemeroids.

The some regularity is detected when comparing species from the temperate and more southern zones. Fig. 2 illustrates the respiration of leaves of three Ornithogalum species after 15 min heatings. It is seen that this function in a tropical species (O. caudatum) is considerably more resistant than in two species from the Caucasus. Protoplasmic streaming, the capacity for plasmolysis and for reduction of tetrasolium chloride are also more resistant in the tropical species.

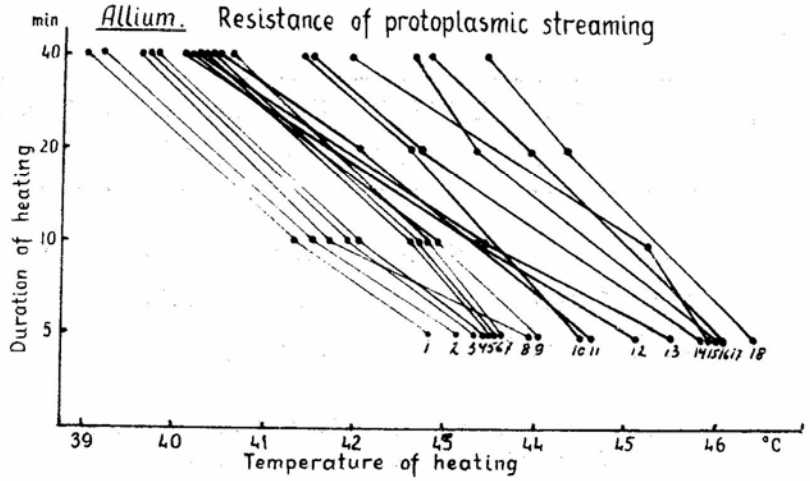

Fig. 1 - The heat resistance of the protoplasmic streaming in epidermal leaf cells of certain Allium species.

a) Ephemeroids : 1. A. stipitatum, 2. A. altissimum, 3. A. karatoviense, 4. A. aflatunense, 5. A. paradoxum, 6. A. gultschense, 7. A. christophii, 8. A. winklerianum, 9. A. suvorovii.

b) Species vegetating over a whole summer : 10. A. oschaninii, 11. A. hymenorrhizum, 12. A. longicuspis, 13. A. pscemense, 14. A. vavilovii, 15. A. filidens, 16. A. lanthum, 17. A. senescens, 18. A. brevidens.

Abscissa : temperature of the heating of the leaves which stops streaming.
Ordinate : duration of heating (logarithmic scale).

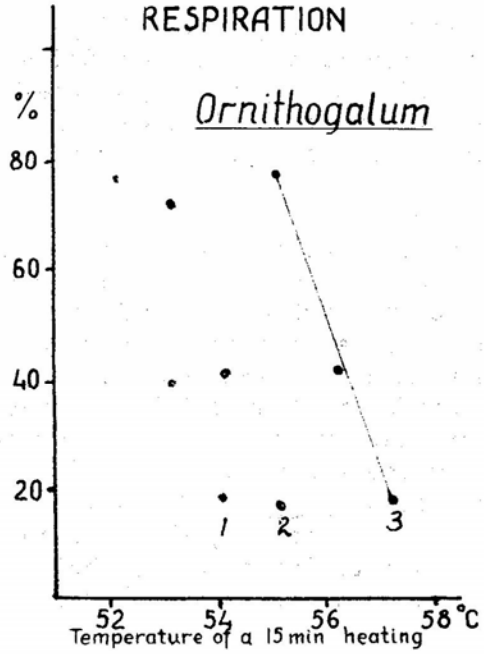

Fig. 2

The heat resistance of respiration in Ornithogalum leaves.
Abscissa : temperature of a 15 min heating. Ordinate : respiration intensity as per cent of respiration in unheated leaves.
1. O. schelkovnikovii ; 2. O. balansae ; 3. O. caudatum.

The lowest primary thermoresistance of cells and tissues was recorded in the arctic and arcto-alpine species. The afteraction of 7 min heatings on the intensity of photosynthesis in two Taraxacum species is depicted in Fig. 3. Photosynthesis is less resistant in the arctic species

T. chamissonis than in T. officinalis from the forest zone. Fig. 4 demonstrates that Rumex arcticus has lower thermostability of respiration than R. confertus. The majority of arctic species studies differ from the forest zone species, also in the resistance of the protoplasmic streaming and in the cell capacity for plasmolysis.

The heat stability level of mature cells in the majority of plants studied proved to be a constant value withing a species. We believe that very frequently this parameter can be used as a diagnostic specific criterion. In several species, however, we found different cellular resistance between northern (tundra) and southern (taiga) ecotypes. For example, Caltha

arctica ssp. arctica from the Wrangel Island (70° North) displays lower thermostability of some cellular functions than Caltha arctica ssp. sibirica taken from the northern coast of the Okhotsk Sea (60° North). These two subspecies are vicarious geographical races. The former is an almost circumpolar arctic race, the latter - a far-east boreal one - extending as far as northern Japan. Distinct delimitation of the two races in regard to different temperature environments is reflected in respectively differing thermostability of the protoplasmic streaming (Fig. 5) as well as of the capacity for plasmolysis. Similar differences in cellular resistance have been detected in the tundra and taiga ecotypes of Rhodiola rosea, Pedicularis sudetica, Artemisia arctica.

The correspondence of cellular thermostability to environmental temperature is revealed also when comparing genera within one family. Fig. 6 shows thermostability of the protoplasmic streaming in leaf cells in differ- ent Amaryllidaceae genera. Plants from the southern subtropics and the tropics exhibit higher thermostability of protoplasmic streaming than those from temperate climates and the northern subtropics. We obtained relevant data

in studying Gramineae. Plants from tropical and. subtropical tribes display higher thermostability of their cells than those from the tribes found mainly in cold and temperate regions.

Taking relative taxa for comparison, one can give characteristics of the floras of various climatic zones with respect to cellular thermostability of plants. Fig. 7 shows the frequency distribution of the heat resistance of protoplasmic streaming in leaf cells in species of the arctic tundra (the Wrangel Island), the northern taiga (the Okhotsk Sea coast) and the arid zone (Turkmenia and Tadjikistan). Among tundra plants prevail those with the thermostability of this function below 43°, while in taiga plants predominate those with the heat stability above 43°. Most plants from the arid zone exhibit thermostability over 46°. Those desert plants which display lower thermostability are, without exception, ephemeras.

The difference in thermostability of cellular functions in plants from cold and hot regions seems to be easily explainable. It can readily be supposed that plants vegetating in the desert, must possess enhanced thermostability of their proteins (and hence, of the cells) in order to avoid thermal denaturation. Which explanation can be given, however, for the difference in cellular thermostability of tundra and northern taiga plants? Boreal

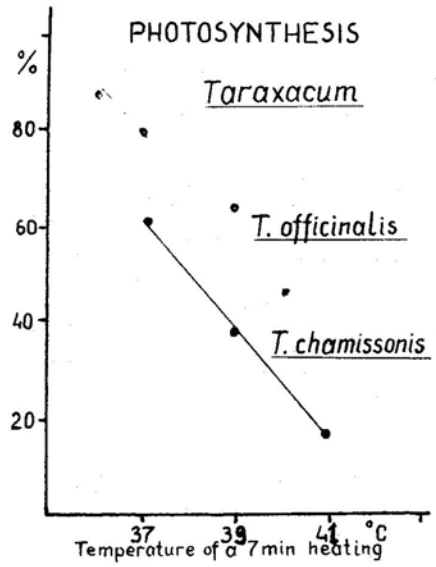

Fig. 3

The heat resistance of photosynthesis in Taraxacum leaves.
Abscissa : temperature of a 7 min heating.
Ordinate : intensity of photosynthesis as per cent of photosynthesis in unheated leaves.

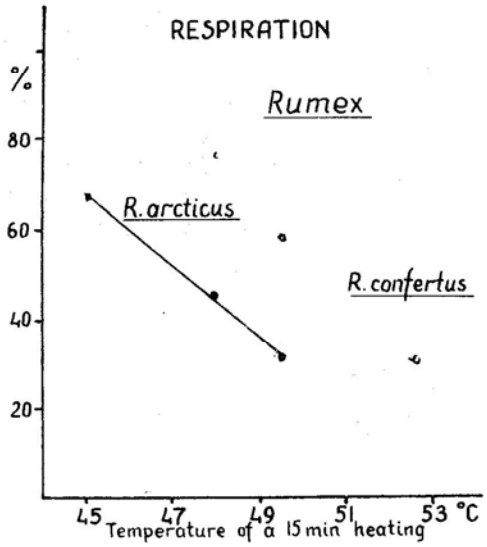

Fig. 4

The heat resistance of respiration in Rumex leaves.
Abscissa : temperature of a 15 min heating.
Ordinate : respiration intensity as per cent of respiration in unheated leaves.

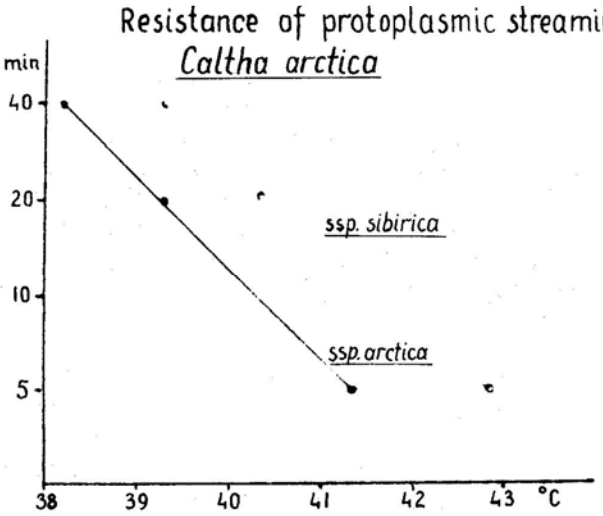

Fig. 5

The heat resistance of the protoplasmic streaming in epidermal leaf cells in Caltha arctica subspecies.
Abscissa : temperature of the heating that stops the protoplasmic streaming.
Ordinate : duration of heating (log scale).

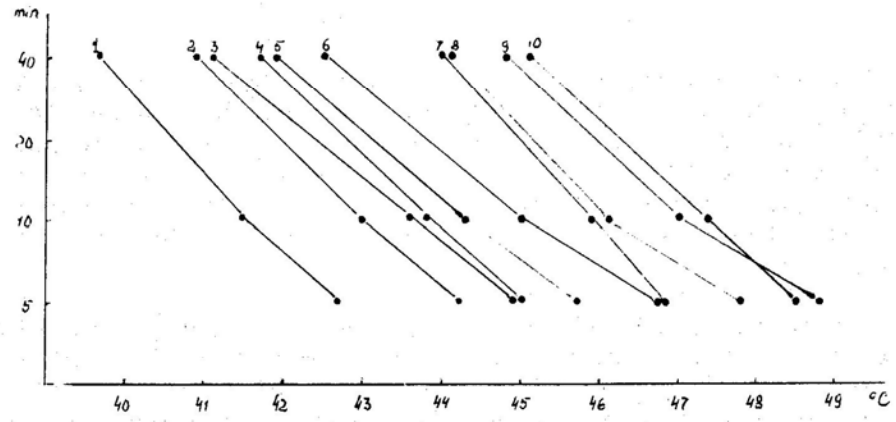

Fig. 6 - The heat resistance of the protoplasmic streaming in some representatives of Amarylludaceae genera.

1. Galanthus platyphyllus, 2. Leucojum vernum, 3. Ixiolirion montanum, 4. Sternbergia fischeriana, 5. Ungernia sewerzovii, 6. Haemantus albiflos, 7. Hippeastrum sp., 8. Crinum commelini, 9. Pancratium maritimum, 10. Zephyranthes rosea.

Abscissa : temperature of the heating that stops the protoplasmic streaming.
Ordinate : duration of heating (log scale).

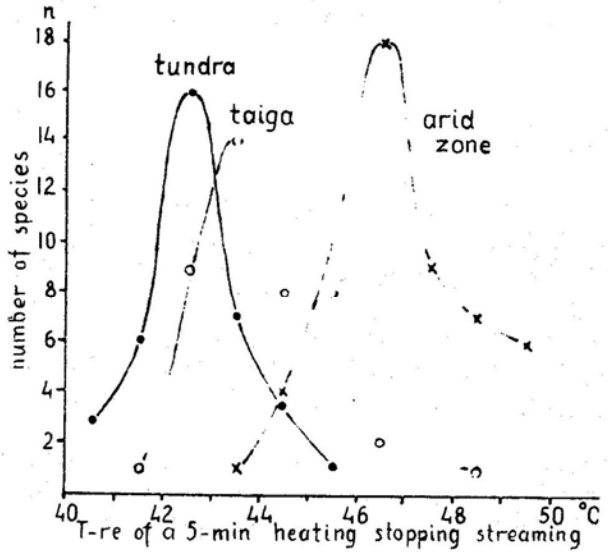

Fig. 7 - Frequency distribution of the heat resistance of epidermal leaf cells in tundra, taiga and arid zone plants.

Abscissa : temperatures of 5 min heatings which stop the protoplasmic streaming.
Ordinate : number of species.

(taiga) species, as compared with their arctic counterparts, live under more favorable though cold conditions. Besides, the arctic flora is a young one. It has been formed through adaptations of the elements of other floras to a more cold climate. Therefore, the question about a decrease in thermostability during adaptation to life at a lower temperature is no less justified than the question of its increase in adaptation to an elevated temperature.

We believe that the answer to this question can be provided if one assumes that cellular thermostability zez. m may have no adaptive significance, but is directly related to a property which is important for the life of an organism at temperatures usual for a given species. We suppose that this property is the degree of conformational flexibility of protein macromolecules. In detail this hypothesis haS been developed by. Alexandrov (1965, 1975).

It is our contention that a correlation between the level of thermostability of cells and the degree of thermophily of a species reflects a molecular mode of plants adaptation to environmental temperature inhCith cold and not climatic zones.

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XIII - Change in organization and activity of photosynthetic apparatus during the first period after altered light intensity

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Abstracts:

'Under control conditions of illumination, temperature, mineral'nutrition, it has been shown that cucumber plants transferred from high light intensity (280 w/M^2) to low one (28 w/m^2), or vice versa, display essential changes in biochemical parameters of a leaf (starch content, relation of protein, protein-free and mineral components), and the rate of accumulation of dry biomass. At the end of the⁻ third day changes in structural organization of chloroplasts also come to an end thus obtaining propertiescorresponding to the new light regime. The possible mechanismCof plant adaptation to altered light intensity has been discussed.

x

According to our previous experiments, plants of the same kind grown for a longer period at various light regimes (intensive, low), develop structural properties, functions of chloroplasts and biochemical organization of a leaf greatly differing at various light intensities and characteristic for a given regime (1-11). These results coincide with those of other authors (12-20).

The mentioned research work suggested to investigate the rate of obtaining the characteristic properties of photosynthetic apparatus at altered light conditions and to state the direct response of physiologically biochemical systems of plant organism to the change of light intensity. Such investigations are comparatively few (21-24), but just these can give the adequate information to understand the plant adaptation to the level of light factor, the mechanism of which has not yet been di4covered. At the same time, these facts appear to be important for plants grown in greenhouses with additional artificial illumination where the effect of changed light intensity on plants is inevitable.

To investigate the direct response of plants to the shift of light intensity series of short-term experiments were organized with daily check of biochemical properties of a leaf, the parameters of structure and functions of photosynthetic apparatus in periods immediately after the change .of light level. The investigation has been carried out on tobacco, wheat and cucumber plants; the results' obtained on all these three plants are in close agreement and, evidently, to certain limits, have the character of a common regularity. In the present report, results are given on the experiments with cucumber plants mainly describing the processes taking place at the replacement of intensive illumination by a weaker one.

Methods:

The cucumber plants were grown in vegetation chambers under controlled temperature, illumination and mineral nutrition. Mercurial lamps APIS-400 were chosen as a light source. To have two levels of illumination two chambers have been organized in one of which the intensity of light reached 280 w/M^2 on the upper leaves which was taken as "high light", in the other chamber it was 28 w/M^2 - "low light". On the basis of our previous experiments, such difference in light levels could be considered as the most effective to display the divergencies in parameters of physiologically biochemical systems of plant staying within the limits of natural illumination (in the latter case, it is close to the lower light level in dense sowings or the greenhouse illumination in winter without additional light).

The plants were grown in water cultures (25) with a relatively low level of mineral nutrition: according to our previous experiments (26), such plant response to changed light conditions is quicker than of plants grown at high nutrition level. The nutrition mixture of the following cpntent was applied:

Element	Element concentration mg/l	Chemical compound
	Macroelements:	
N	21.6	$Ca(NO_3)_2$; NH_4NO_3; KNO_3
Ca	13.5	$Ca(NO_3)_2$
K	19.6	KNO_3; KH_2PO_4
P	3.1	KH_2PO_4
Mg	32.0	$MgSO_4$
Fe	11.0	$C_3H_4OH(CO_2)_3Fe$
	Microelements:	
Mn	0.15	$MnSO_4$
Zn	0.04	$ZnSO_4$
B	0.14	H_3BO_3
Cu	0;03	$CuSO_4$
Mo	0.04	$(NH_4)_2MoO_4$
Co	0.02	$Co(NO_3)_2$

The complex forming Na2-EDTA (trilon-B)) as much as 40 mg/1 was also included in the nutritive mixture for maintaining the ionic balance of trace element salts in nutritive solution (27, 28).

Two experimental series were organized: in the first one the plants were grown in chamber with high light intensity (280 w/m^2) till to pairs of leaves appeared, then part of the plants were transferred to another chamber with low light intensity (28 w/m^2); in the second series, the process was quite opposite; after the appearance of the second leaves, part of the plants were transferred from low light intensity to the high one. The planned records and sample fixation for analyses was done directly before the plant transference to new light conditions (at the initial state) and then daily after transferring during 4 or 5 days. The other part of the plants was left under the initial light regime as a control.

The investigation was done on:

1) The dynamics of dry weight of biomass: leaves, stalks and roots were separately dried at 105° C to the constant weight; dry weight of the total biomass was obtained by summing up.

2) The state of ultrastructure of chloroplasts and products of photosynthates in them by means of electron microscopy TESLA-BS-513 using glutaraldehide fixer on cacodilate buffer; preparations were contrasted by phosphotungstic acid, uranilacetate and lead citrate; sections were made by ultra-microtome TESLA-BS-490. At 18.000-fold photo enlargement, the area of chloroplasts was measured by means of a measuring net) and the mean area was calculated wite 30-fold repetition. The third (fully grown) leaf was investigated.

3) The function of photosynthetic apparatus was investigated by characterizing the light curves of photosynthesis of the third (fully grown) leaf on the infrared recorder Infralyt-2 reconstructed according to the differential scheme (29).

4) The starch content in leaves was determined by ncCready's method (30), the soluble carbohydrates, by the application of enthrone reagent (31, 32) and the protein nitrogen, by the Kjeldahl's micromethod with Barnstein's sedimentation. The plants were collected for analysis at one and the same time (from 9 till 10) and dried lyophillically; the mean sample was constituted of 10 plantb.

5) In the polar lipids of chloroplasts extracted according to Folch's method (33) and purified by column and thin-layer chromatography, fatty acids were stated in the form of methyl esters by gas-liquid chromatography as already has been described before (34). At the same time, content cf lipid peroxides was determined in chloroplasts by the thiobarbituric acid test (35).

Results:

Registration results of the total dry weight of plants transferred from high light intensity to a low one are presented in Table 1. These results allow us to state a significant decrease in the rate of dry biomass

Table 1 - Effect of lowered illumination intensity of plants on the dynamics of the total dry weight (g per 10 plants).

Light intensity	26.VI (before experiment)	27.VI		28.VI		29.VI		30.VI		1.VII	
		g	%	g	%	g	%	g	%	g	%
280 w/m^2 (control)	1,7 ± 0.05	3.4 ± 0.2	100	4.5 ± 0.15	100	5.8 ± 0.2	100	6.8 ± 0.2	100	8.2 ± 0.45	100
28 w/m^2 from 26.VI	(1.7)	2.4 ± 0.1	70.6	2.8 ± 0.15	62.2	3.9 ± 0.1	67.2	4.9 ± 0.3	72.1	5.8 ± 0.2	70.7

Table 2 - Effect of lowered illumination intensity on the content of carbohydrates in plant leaves (% per dry weight)

Light intensity	26.VI (before experiment	27.VI	28.VI	29.VI	30.VI
		Starch			
280 w/m^2 (control)	5.89 ± 0.21	6.73 ± 0.03	11.28 ± 0.34	10.29 ± 0.01	11.27 ± 0.12
28 w/m^2 from 26.VI	(5.89)	1.99 ± 0.05	2.26 ± 0.19	3.72 ± 0.00	3.49 ± 0.02
		Soluble carbohydrates			
280 w/m^2	2.55 ± 0.03	2.75 ± 0.12	3.50 ± 0.30	3.64 ± 0.09	3.83 ± 0.05
28 w/m^2	(2.55)	2.87 ± 0.06	4.47 ± 0.09	3.24 ± 0.28	3.66 ± 0.21

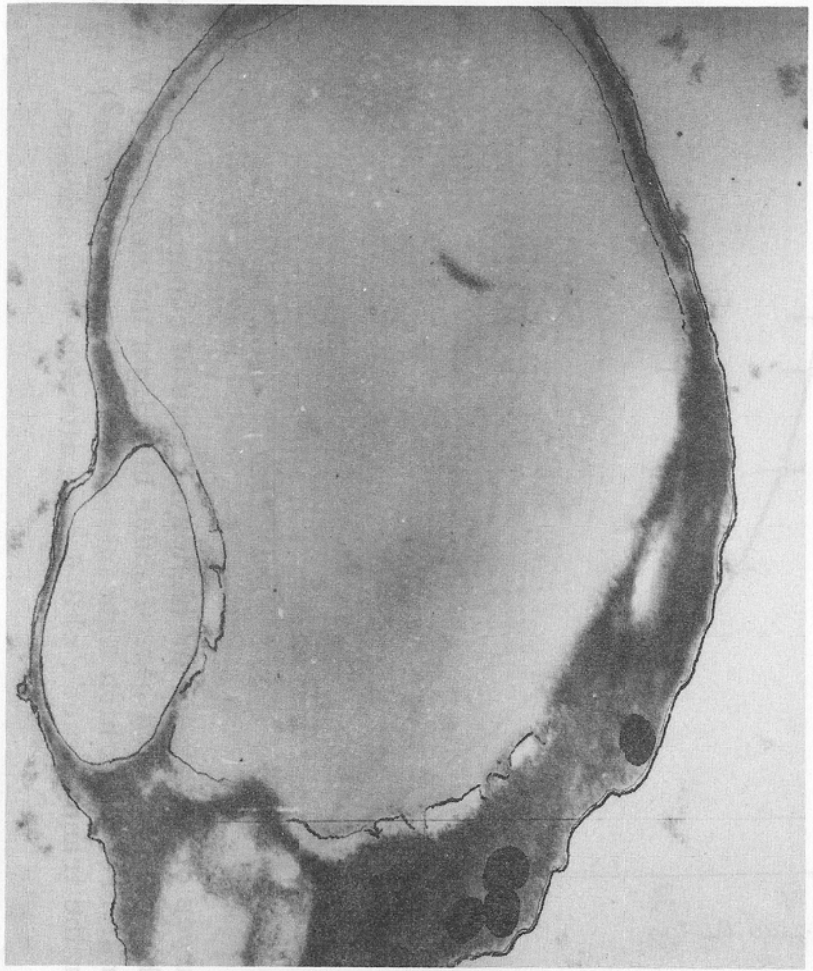

Fig. 1a

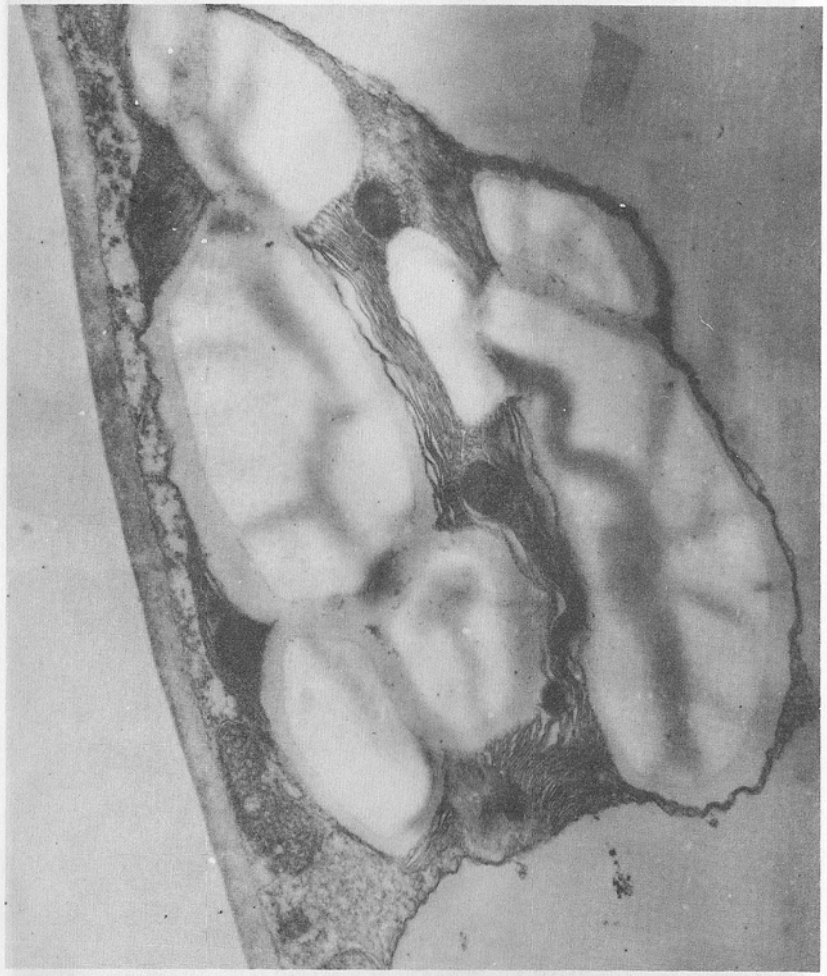

Fig. 1b

Mesophyl chloroplasts of cucumber plant leaves : a) being under high light intensity (280 W/m^2) during the whole observation period ; b) one day after the transference from high light level to low one (28 W/m^2).

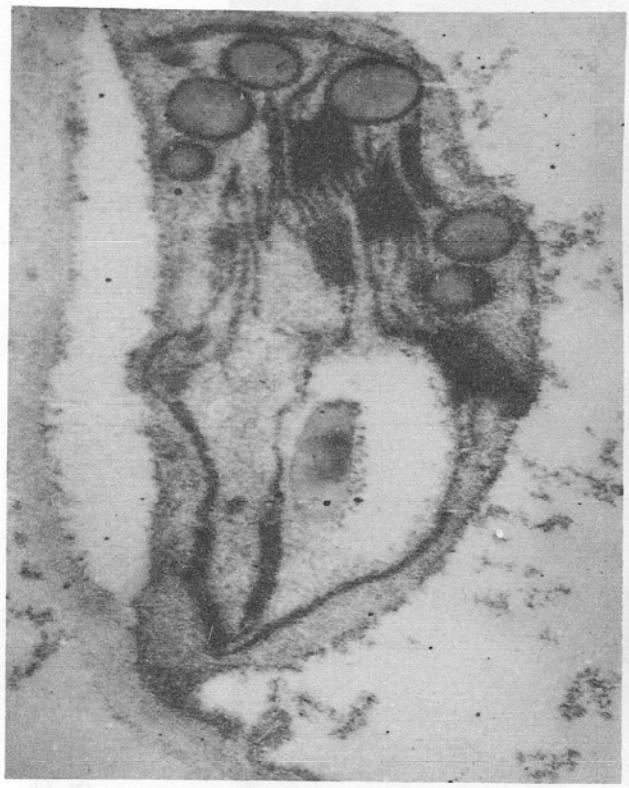

Fig. 1c

Chloroplast formed de novo three days after the transference.

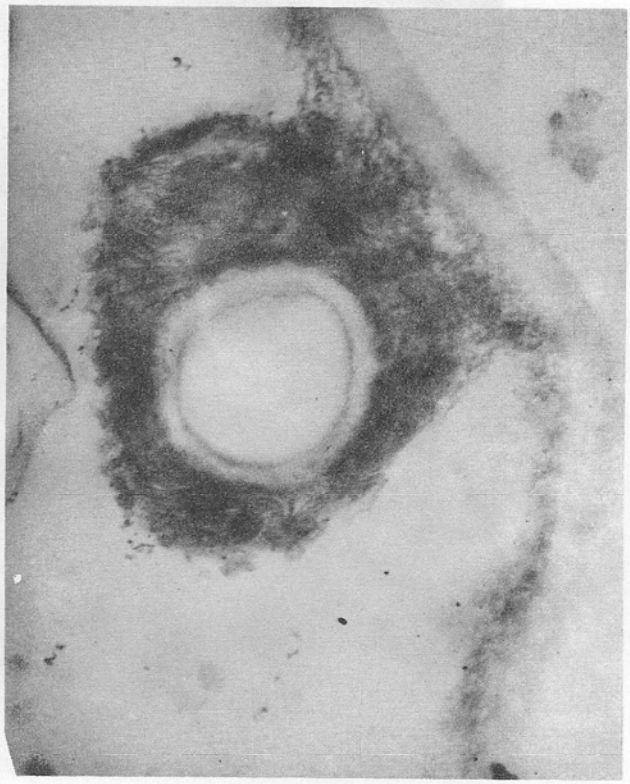

Fig. 1d

Chloroplast originated from the division of the old ones.

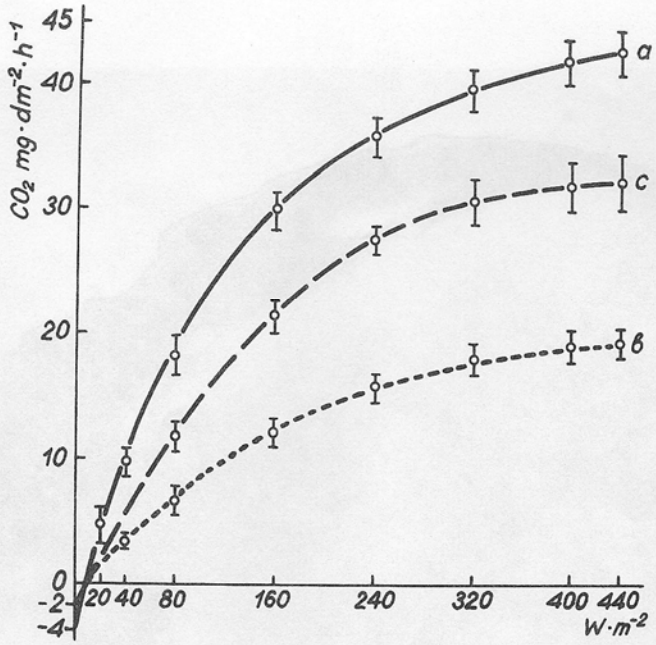

Fig. 2 - Light curves of the appearant photosynthesis of cucumber plant leaves : a) the whole observation period under high light intensity (280 W/m^2) ; b, c) transferred from high light intensity to low one (28 W/m^2) ; b) one day after the transference ; c) 3-6 days after the transference.

gain (on the average for 30) for plants transferred to lower light intensity for a day already. And these new less intensive rates of gain remain the same to the end of the observation period.

When analysing the causes of such strong hindrance of biomass weight gain, it turned out that the starch content in leaves had changed rather considerably. As can be seen from Table 2, the first days after transferring. the plants to new light conditions, the content of starch decreases almost three times when compared to the control plants which were left under intensive illumination; further on, the content of starch remains about the same low level to the end of the observation period, with about the same differences between variant and control. According to Table 2, the content of soluble carbohydrates remains almost constant till the end of the observation period. The importance of a certain amount of starch present in a plant leaf for maintaining a number of significant physiologically biochemical parameters of plant has been demonstrated beforehand for several cultures (10).

The change of starch content in a leaf during the same first days automatically causes quantitative changes in the size of ratio of protein substances to carbohydrates as well as in the concentrations of mineral nutrients in leaf tissue: according to the decrease in starch content, both indices are increasing (Table 3 - as to the tasks of the present announeement, the content of mineral nutrients will be expressed as a sum of three main macroelements: nitrogen, phosphorus and potassium).

Thus, literally in some hours after the shift of light conditions, the relative part of protein compounds increases for several times in the protoplasm of leaf cells and the concentration of mineral compounds increases more than tWo times, i.e. significant changes take place in the biochemical organization of the organ of photosynthesis.

Electron-microscopic investigation6 of chloroplasts confirm the high rate of changes in the reserve of assimilating polysaccharides when altering .the light intensity (Fig. 1). Just before transferring the plants to lower light intensity, a chloroplast contains ore, seldom two large granules of starch (Fig. la). During the first hours after the effect of less intensive light, the starch granules fall apart (Fig. lb), getting very quickly smaller and smaller. The desctructionof polysaccharide granules dominates during the first days after the light shift. On the third day, alongside with the old large chloroplasts like lb, a great number of new small chloroplasts (which are formed either de novo (Fig. lc) or derived from the division of the old ones (Fig. 1d)) are being observed in the assimilating cells. Due to the appearance of the prevailing number of new small chloroplasts, the mean size of a chloroplast decreases, which is proved by the results of their areal measures presented in Table 4. Division of chloroplasts and appearance of new ones at altered light intensity has been observed by one of us before, but then it concerned the change in the light spectrum towards the increase of ultraviolet radiation (36, 37). It is quite possible that this process will .prove to be a widespread response of the plant to a relatively sharp change of one or another factor of environment.

As can be seen in Figures lc and ld, the structural orgenization of newly formed chloroplests at laver light level essentially differs from the initial one and approaches that of shade habitat plants which are characterized by the absence of considerable polysaccharide accumulation and a rich development of pigment carrying system (7, 16). As it has been shown in the article by Selga and Rudj (7), the plants grown in the shadow and at a low level of mineral nutrition are characterized by chloroplosts of a comparatively small size like those obtained at the experiment on the third day after plants being at lower light intensity.

The appearance of a prevailing amount of a *new* type of chloroplasts with an organisation structure more corresponding to the new light conditions allows us to state the plant adaptation to the given light conditions, which occurs during the very first days after the transference.

According to the investigations of the function of photosynthetic apparatus (Fig. 2), the parameters of light curves of photosynthesis stabilize at about the same time. During the first days after the change in light intenuity, a considerable depression of photosynthesis occurs; the light curve of transferred plants (rig. 2b) is placed considerably laver t:.2n the men:: light curve of the control plants (Fig. 2a). But this depressien nesniting from lowered light intennity appeared to be rather short. On the escond and third dan, acme "straighteninn" of the light curves has been obeereed a= well as the improvement cf their parameters (Fin. 2c) which however did not reach the parameters of light curves of the control plants (e). On the 4-Sth day, the light curves are close to those of the third day, which allows us to state the stabilization there. (Fig. 2c presents the meanleelne curve far plants on the 3-6th day after lowered light intensity.)

It should be mentioned that respiration under low light level also creases considerably (about twice) at the first period after transferring the plants to lower light intensity (this can be told from the disposition of the initial points of the light curve). This difference in levels is preserved to the end of the observation period and possibly throughout the plant life, which can be seen from the results of our experiment performed earlier (38, 39) and from the data of other scientists (40).

Response of plants transferred from low to more intensive light was rather opposite to that described above; a detailed description of the results will be given in a separate report. Here we are describing only the general characteristics of the main relationships obtained.

During the first days, when the plants were under more intensive light, the weight gain of dry biomass as well as the starch content in leaves increase twice. The level of soluble carbohydrates remains about the same (10).

Electron-microscopic investigations of ultrastructure of chlercplasts when transferring plants to intensive lieht discovered that chloroplasts were increasing in size and their covers thickened. And polysaccharides, previously few or absent, quickly form and increase in size. The relationship between the sizes of pigment carrying system and strona decreases. Chloroplasts of typical shade habitat plants with widely developed lamellar structure, like those in Fig. ld, become like those in Fig. In on the third or fourth day after increased light intensity, and in the given case, this

process occurs on the basis of old chloroplasts without division or new formation.

A characteristic feature of adaptation to high light intensity appeared to be the change in lipid composition of photosynthesizing membranes - the decrease in unsaturated fatty acid content within the polar lipids which resulted from an increase in peroxidation of lipids. This causes an inhibition in photochemical activity of chloroplasts and thus limited the development of peroxidation (41-43) and it positively affected the plant adaptation to high light intensity (34).

The described biochemical and structural changes as well as rate changes in biomass weight gain in the case of plant transference to more intensive illumination occur and come to an end in some days, just after the shift of light conditions. As can be seen from our long-term enperiments with weekly registrations (28), there are further chengee in the sere direction, but they are very slight when compared with those of the first days.

When summarizing the obtained results, it can be concluded· that the adaptation of the physiologically biochemical systems of leef and chloroplast to the new intensity of light occurs rather quickly, no that in eboet three deys they can be considered edapted. The active proceseee of mobilization (or, vice verse, formation) cf starch observed in chlcroplantn during the first days, result in sharp changes in the relationship between protein and protein-free components, mineral and organic components in cytoplase and plastids which determine considerable as well an comparatively quick changes in chloroplast structure (on the basis of old chloroplasts or by their division) concerning the advantageous development of pigment carrying membranes or stroma. Due to that, during this short period, the greatest amount of thloronlasts obtain characters mainly corresponding to the new light regime. The impulse from chloroplasts, obviously, provides the adaptation state for the whole plant organism, as according to the date given above, changes in the growth rate of leaves, stelks and roots also come to an end mainly at a three day period. And the increased growth rate characteristic for stalks under low light intensity (and inhibited under high light intensity) hos been displayed and its rate stabilizes mainly during three or four days just after the change of light conditions (28).

It should be noted once more that the obtained facts and the described adeptation processes concern plants grown at a rather low level of mineral nutrition which was necessary for the methodic aims (see "Methods"). The study of other nutrition levels discovered (26, 43) that the adaptation showed the dependence on mineral nutrition level and, generally corresponding to the above given scheme, in anumber of features it essentially differed in the case of plants with better supplied root nutrition.

Conclusions:

1 - When transferring the cucumber plants from high light intensity (280 w/M2) to a low one (28 w/m2) or vice versa, the most expressed changes in physiologically biochemical parameters of a leaf and chloroplast have been observed during the first three days after the shift of light regime.

2 - When transferring plants from high to low light, intensive hydrolysis of starch occurs in chloroplasts, its level decreases several times when expressed in the dry weight of leaf, the ratio of protein substances to carbohydrates and mineral to organic matter increases; the activity of photosynthesis (light curves) and the rate of biomass gain decrease. On the third day, the structure of chloroplasts obtains clearly expressed properties characteristic for shade habitat plants.

3 - When transferring the plants from low to high **light intensity, the** physiologically biochemical changes occur in an opposite direction and are of the sane rate. A decrease in unsaturated fatty acids has been observed in the polar lipids of chloroplasts at the adaptation to high light intensity.

Table 3

Effect of lowered illumination intensity of plants on the ration "proteins/carbohydrates" and the content of mineral elements in plant leaves.

Light intensity	Ratio "proteins/carbohydrates"		(N + P + K), % on dry weight	
	26. VI before experiment	27. VI	26. VI before experiment	27. VI
280 w/m^2 (control)	0.05	0.04	2.06 ± 0.10	2.00 ± 0.10
28 w/m^2	(0.05)	0.27	(2.06)	4.72 ± 0.34

Table 4

Effect of lowered illumination intensity of plants on the mean area of chloroplast at 18.000-fold enlargement (the mean of 30 repetitions).

Date	Light intensity	Area of chloroplast cm^2
26.VI (before experiment)	280 w/m^2	32
28.VI	28 w/m^2	20
29.VI	28 w/m^2	16

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XIV - THE EFFECT OF SOIL WATERLOGGING ON VARIOUS PHYSIOLCGICAL PRCCESSES IN MAIZE

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University of Utrecht, the Netherlrnds

INTRODUCTION•

By waterlogging, gaseous exchange between soil and atmosphere is severely reduced. Plants grown before in. well-aerated soil are therefore deprived of oxygen nnd exposed to high concentrations of carbon doixide that accumulates, due to anaerobic dissimilation. Besides, various by-products which are partly hareful to the living tissues are appearing. Most plants are sensitive to a sudden change from well-aerated to un-

aerated conditions and are responding by a reduction of various activities. The degree of reduction wxies markedly from species to species. *Since* the root environment changes in a rather complex way, many attempts helve been merle to unravel the situation into, single factors. In general, we may conclude frem the results obtained,thet species differences are, not restricted to the response to one single factor. So: e.g. Plants, which tolerate a low concentration of oxygen are able to endure also higher concentrations of carbon dioxide, ethylene and alcohols. The species adaptetion'Seems to concern more than One of the factors involved.

One way of adaptation is the formation of air channels in the cortical .region of, the roots which are connected with the intercellular spaces in the shoot. By this means, maize roots are able to grow in uneereted conditions to varying depths. The variation depends on the metabolic activity. The higher this activity, the smaller the distance that can be bridged.

In the present paper, phenomena are described that occur when a formerly well-aerated root system is suddenly deprived of gas exchenee by waterlogging of the soil.

MFTHODS

In eech of severel two liter pots with fertile garden stoil maize seeds were planted. They were grown in a greenhouse of +/- 20° C. up to the 9th leaf stege.

The experiments proper were performed in a moderately controlled room, where we had the opportunity to registrate automatically the leaf elongation rate, the transpiration rate of a parcitular leaf and the rate of photosynthesis of another leaf together with light intensity, temperature and air humidity.

In the experimental room, the plants were exposed to 18-6 hours Light-dark cecle, the light intensity was *on* an average 10^5 erg cm-2 s-1 and the tempereture was 25°-27° C. Air humidity was about 20% relative humidity.

Two pots with four pants each were placed in the experimental rcca and during the first 24 hour period, the above mentioned urocessee were followed on one plant of each pot. After 24 hours, one pot was flooded and the measurements were continued for 4-5 days. At raeular intervals the other three plants' of the same pots were cut for analysis of the exudation rate, the ionic composition of the exudate and the chlorophyll content of the leaves.

Some of the cut leaves were used to measure the tiee course of water loss on a recording balance and some others were placed with their base in a 0.5 %eosine solution, in order to determine the rate of ascent of sap in the xylem vessels.

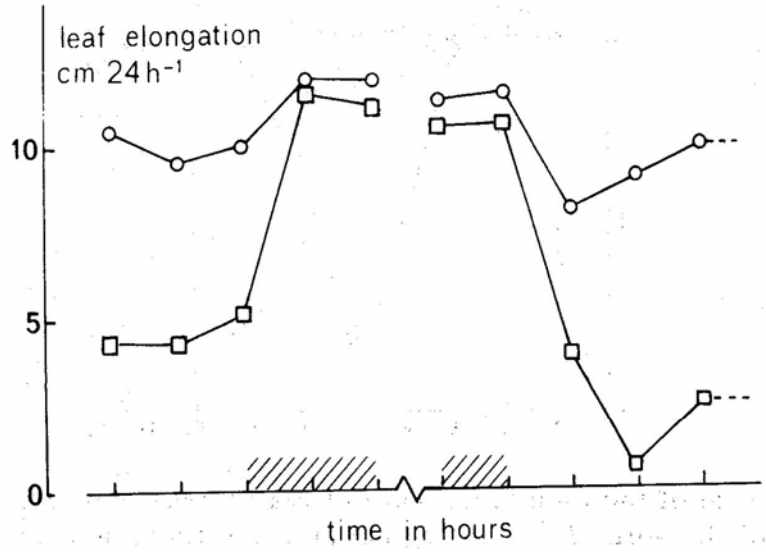

Fig. 3 - Response of the elongation rate of maize leaves to the transition from light to dark on the third day and to the transition from dark to light on the fourth day after the soil was inundated. Circles : control plants ; squares : treated plants.

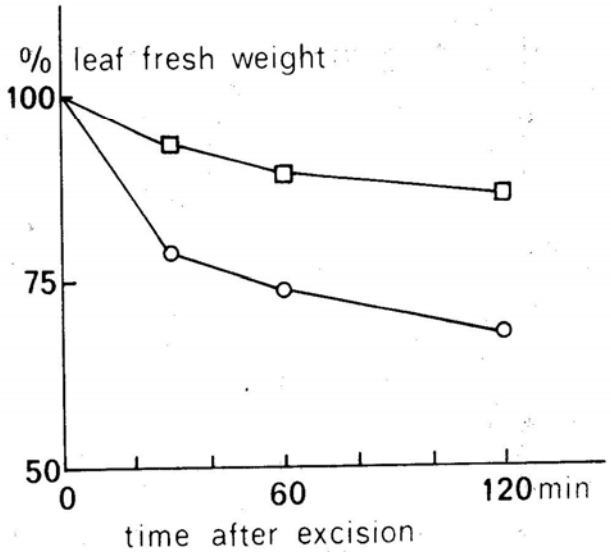

Fig. 4 - Time course of the weight loss of maize leaves after cutting. Circles : from control plants ; squares : from treated plants.

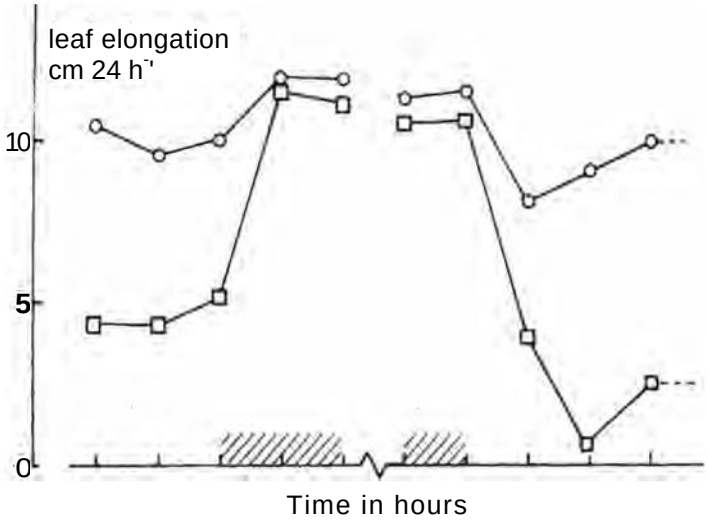

Fig. 3 - Response of the elongation rate of maize leaves to the transition from light to dark on the third day and to the transition from dark to light on the fourth day after the soil was inundated. Circles : control plants ; squares : treated plants.

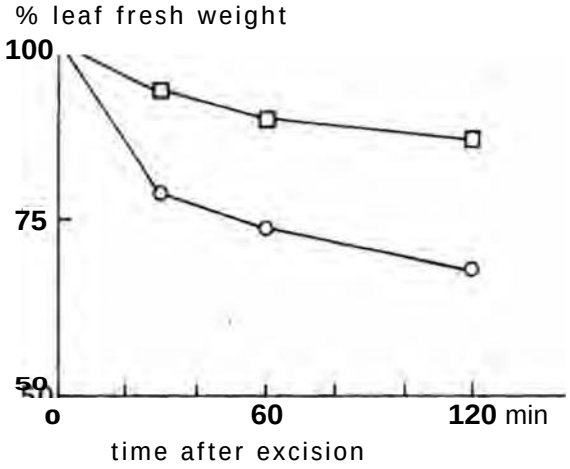

Fig. 4 - Time course of the weight loss of maize leaves after cutting. Circles : from control plants ; squares : from treated plants.

RESULTS AND DISCUSSION

About one hour after the beginning of sledding, leaf elongation rate of the treated plants slowed down, which was followed by a spontaneous recovery (fig. 1). This short time response will be published in detail elsewhere and can be ascribed to a temporary decrease in water permeability of the root tissue. The almost normal level afe ter recovery lasted for at least one whole day, mostly for two days (fig. 2). During these two days, the effect of flooding is completely reversibel. After two days, a continuing decrease in leaf elongation rate is seen which results in a complete check during the 5th day. It is obvious that the reduction in leaf growth is much more pronounced• during the light period than during the corresponding dark period (fig.2).

This response is presented in detail in fig. 3. At the end of the light period of the 3rd day, the leaf elongation rate amounted to about 50%, of that of the control. After the lights were switched off the elongation rate inmed4ntely reached the control level and stayed there over the whole night. Switching on the light resulted in a severe reduction of the elongation rate already during the first hour The ultimate level during the 4th day ',as considerably lower than that of the preceding day.

It should be noted (fig. 3) that after the transit ion from light to dark and from dark to light, the growth of the leaves of the control plants responded in the same direction, but mach less pronounced. This response has to be ascribed to changes in water potential in the plants due to the light effect on transpiration (Meieenorst an Brouwer, 1970, 1972; Brower, 1974).

Figure 2 further shows that prolonged inundation reeelts in e gradual decrease in the rate of photosynthesis, which also falls to zero in the course of five days. Since the chlorophyll content of the leaves of the treated plants (Brouwer, 1975) also decreased from the third av onwards and reached a value of 50 % of that of the control during the 5th day, the question arises whether the reduction in photosynthetic activity was ceused by stometel closure or chlorophyll breakdown. Presumably the stomatal reaction is more important since it appeared, that the transpiration responded in a comparable way. We did not make direct measurements of stomatal opening, but followed the fresh weight- of control leaves and treated leaves after excision (fig. 4). The rate of water. loss of the latter was considerably less and showed only a slight decrease in time, whereas the leaves of the control plants transpired rather fast in the beginning with a severe reduction after about 30 minutes. It may be assumed that the initial slope is a measure of • stomatal opening (Hygen, 1951). This slope is affected by the treatment (S in figure 2, bottom). The time course perellels more or lees that of transpiration and photosynthesis on the understanding that the remaining value of the cuticular transpiration limits the possible reduction of both T and S. As a matter of feet, the etceete wore (ire7iltretion method) closed completely during the light period on the 5th day. It can be concluded from these data that the responses mentioned so far are consequences of the effect of waterlogging on the water

status of the plants. The primary effect of waterlogging is a severe reduction of metabolic activity. As mentioned elsewhere (Brouwer, 1975) this leads to a complete check of ion-absorption and osmotic water-uptake. It leads also to a reduction of the synthetic activities of Che- roots so that, for instance, the cytokinin production is strongly diminished (Grable, A.R., 1966).
However, the latter phenomena don't have any significance for leaf elongation, transpiration and photosynthesis in short term experiments, the reduced metabolic activity additionally affects-the condition of living membranes (Kramer and Jackson, 1954), which Induces change6 in water permeability. In our experiments, we only observed decreases of permeability with transpirational conditions remaining the same,.ultimately leading to a reduced-water potential (fig. 2, top). The increase in root resistance-to waterflow – does not appear at once (with the exception of the transitional changes during the first two hours), but gradually.
The lower water potential induced .via the reduced water permeability can be seen as a causal factor for the decline in leaf elongation rate (first sign) and subsequently for the closure of stomata and the reduction in transpiration and photosynthesis. Although the responses reported so far can be fully explained via the effect of waterlogging on the water balance of the plants, waterlogging is also affecting plant behaviour in other ways when measurements are performed over longer periods of time. Probably the rest step is the decay of chlorophyll indicating anticipated senescence. The chances are that lack of kinetin production is involved in this particular response. In some of our experiments a alight recovery could be obtained by spraying benzyladenine on the leaves (Brouwer, 1975).

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XV - LABORATORY MATERIAL

Haake Thermostats, Dieselstrasse 4, D-7500, Yarslruhe 41, Federal Republic of Germany

Representative in .France: Heraeus France, Zone Industrielle, 91401 Orsay, P.B. N°18,France

Large range-of thermostats: 1) analog, of variable capacity between 3 and 12 liters, temperature variations between -30° C and 120° C; 2) digital, of variable capacity, between 3 and 19 liters,temperature variations between -50° C and 200° C.

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XVI - PUBLICATIONS OF E.S.".1..

The European Society of nuclear Methods in Agriculturepublizhed two documents for which we give the Table,of Contents. Those desiring to receive these documents should write to: Secretariat E.S.Y.A. MAL, Postbus 4', Wageningen, The Netherlands.

1 - Radiation for pollution abatement - Proceedings of the. firbt International Conference of E.S.N.A. working group on ':!aste Irradiation. Munich, 8-11 June 1976, 250 pp.

Contents: Introduction by A.F. Groneman
771=tion problems in Agriculture:
- Problems in the use of municipal wnstes in agriculture.
- Review ofpollution problems in Dutch livestock production and waste water production by the agricultural industry.Z.H. Voorburg.

b) Dosimetry:
- Dosimetry in the Megarad Range by means of ESR-spectrOScopy on Free Radicals of Amino acids. D.F. Regulla, U. Deffner.

c) Disinfection and microbiological control:
- Investigations of the effect of electron-beam•irradiation On. bacteries in servage sludge. G. Osterstoci.
- Data on the irradiation of liquid manure, artificially'infecteri Foot and Mouth. Disease virus. J. Simon et al. ,
- CGR-MeV Programme for 'dater and Liquid sludses Treatment•with High-energy electron Beams-Preliminary investigation. C.L. GalIien et al.

Thermoradiation treatment of servage sludge using rector •t-,.ste to obtain acceptable fertiliner or animal supplement feed. H.D. Sivinski.

- E:rperience with a pilot plant for the irraMation of servage sludge. Bacteriological and parasitological studies after irradiation. T. Wizigmann.

d) Chemical and physical modifications:

- Effects of gamma irradiation on physical-chemical properties and watering characteristics of sludges. - A.F. Groneman.
- Influence of gamma irradiation on the behaviour of servage sludges. - W. Hegemann and W. Gunthert.
- Effects of Gamma-radiation on the degradation of arabstituted aromatics and of industrial, waste water. - E. Gilbert.

e) Pilot plant design and operating experiences:

- The technology and economics of treating waste water with electron beam radiation. - V.R. Cleland.
- The pilot plant in Geiselbullack for the gamma irradiation of servase sludge-design, operation experience and cost calculations. - T. Lessel and E. Hennig.
- Concept for continuous sludge irradiation with radio-isotopes. - B. Herkart.
- Duality and security on the uses of cobalt 60 sources for industrial irradiation. - J. Dearoches.
- Servage sludge irradiation with electrons. -M Tauber.
- Technical and economical aspects of a largo and a small plant for irradiation of liquid waste. - E. Eerrrhut et al.

f) Use of sludge in agriculture.

- Experience with differently treated cewage sludge in agriculture. A. Suss et al.
- Chemical analyses in sewage sludge after•diffsrent-treatenLs. - R. Stark et al.

g) Final session:

- Conclusions and recommendations: I) On disinfection. - .II) On the separation of solids from liquid. - III) On design and operation. - IV) On cost benefit analysis. - V) On the use of sewage sludge in agriculture.

2 - Peport working group "Nuclear techniques in the study of soil-plant relationships" - VIIth Annual meeting, Warszawa, September 1976, 73 pp.

Contents: report of the Chairman.

- Geijn, C.C. van de - Autoradiegraphy, its principlesani core general considerations on its application to moils and plants.
- Moskal S. - Comparison between "A-values" and "3-values" as a measure of available phosphate in different soils.
- Hernando V. and V.T. Fordo - Relationship between the release of phosphate from soil and its rate of uptake by plants.
- Shiba *T.* and Lasota - Accumulation of nitrogen in spring wheat grain from fertilizers applied at different stages of growth.

- Filipovic R. - Studies on utilisation of nitrogen fertilizer addes duri•E; souring and sidedressing of wheat in presence of organic matter.
- Sutae G.E. et al. - Transformation rated of 15NH4 and 14NH4 in soil.
- Wieneke *J.* Ion specific absorption of salt tolerant and salt sensitive soybean mutants simultaneously labelled by 36 Cl, 22 Ka, 45 Ca and 28Mg.
- Sauerbeck D.R. and B.G. Johnen - Formation and transformation of Plant roots in soil.
- Apostolakis C.G. et al. - Nitrogen-15 in fertilizer utilization and growth of wheat studies in Greece.

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XVII NEW FERIODICALS

- Agricultural Administration

Edited by Applied Science Publishers Ltd..
Ripple Road, Barking, Essex, U.K.

4 issues per year. A forum for exchanging experiences and ideas on administration between countries, commodities, production systems and social systems.

- Aricultural Systems

Edited by Applied Science Publishers Ltd. Ripple Road, Barking, Essex, U.Y.

The results of studies of entire agriculture systems or relevant parts of them are published here.

Irrigation Science

Edited by Springer international Verlag.

Original contributions and short papers on irrigation resea.rch including plant, soil and atmospheric science S, as well Hs the analysis of field experimentation.
1977 vol. I - 4 issues per. year ,loined to one volume D.M. 148.

- Environmental Monarement

Edited by Springer Verlag.

High level exchanges between science, engineering, political science and law.

1977, vol. 1 - 6 issues per year in one volume D.M. 144.

- Perspectives agricoles

Subscription: Les Editeurs et Publications Agricolcs- Fr-''mgaises, 3 Avenue du President Wilson 75016 Paris, France.
Monthly revue of 64 pages or more, with cover page in color, 21 x 29,7 format, N°1 January 1977.

This French lanli.mge periclicel on agricultural techniques of the Te:tnic.-1 Institute of Cereals and Forage Grass will publish: current technical information, a justification for advice given, the results • of tents on v7rieties, defoliants, insecticides, fungicides, machinery andequ4pment, ate., conclusions of studies on the quality of harVests, the techniques and the costs of production, systems of raising plants, etc., and is capective m-rketc for cereals and forage grass. •
This periodical is recommended for all professionals working in agriculture.
The first issue includes the following chapters: a seasonal study, agronomical perspectives, equipment perspectives, breeding perspectives, economic perspectives.

XVIII - HANDBCOY Or PLASTICILTUPE

by Professor-P. Dubois.

In 95 pages of text and with 25 figures (21 29,7 format), the author demonstrates the fundanental importance of plastic in plant production. The use of plastics, in fact, appears from thg time of pacImging (seeds, fertilizers) until•the time of harvest and including ground protection (mulching), plant development (tunnels, shelters, greenhouses) and irrigation (reservoir and distribution).

The contents of this booklet are presented in a didactic and scmewhat concentric way, but a monograph of each subject can be established by referring to the alphabetical list of key words.

Contents:

Chap. 1 - Généralités sur la plasticulture: objet, matériaux courants, biologie végétale.

Chap. 2 - Construction en général et en plasticulture à partir d'un bref rappel sur ces matériaux aux points de vue: mécanique, optique, thermique, chimique.

Chap. 3 - Rôles des principaux matériaux dans les principales applications: filsm, canalisations, plaques et profilés.

Chap. 4 - Mise en oeuvre des semi-produits précédents en considérant l'orientation, le vieillissement, l'assemblage après découpage, collage, soudage.

Chap. 5 - Plasticulture champêtre d'après les différents outils de la plasticulture: paillis, tunnels, serres, méthode et génie rural dans chaque cas.
Questions diverses; culture hydroponique ... écologie.

Chap. 6 - Marques de Qualité : films, canalisations.

Chap. 7 - Récultats de la plasticulture: Précocité et rendement. Sécurité et conservation des récoltes.

Chap. 8 - Origine - Evolution - Prospective - Economie mondiale.

Chap. 9 - Bibliographie - Périodiques

Chap.10 - Comité des plastiques en agriculture. Organigramme.

Chap.11 - Table alphabétique des mots clés, des auteurs et des plastiques agricoles.

Editeur: Centre d'Etudes des matières plastiques, 21 rue Pinel, 75013 Paris, France

XIX. LIVRES NOUVEAUX
LIST OF NEW BOOKS

- C.V. ANDREEV and al. Methodes biophysiques de protection des plantes des depredateurs et maladies (en russe). Edition Kolas, Leningrad, 1976, 168 p.

- D. ZOUHOT et J.M. LEFEBVRE. Maladies et accidents culturaux.des cucurbitacges. Methode de lutte. Edition bilingue, francais et anglais. Renseignements : P.-H.M. 59, rue du Faubourg Poissonniere 75009 Paris, France.

- G. GALLEN. Les coniferes cultives en Europe. Editions Bailliere, 19, rue. de Hautefeuille 75006 Paris, France.

- Compte-rendu du Colloque sur les plastiques en Agriculture (Hy6res 25-27 f6vtier 1976). 116 pages, 50 F. Edition : Comite des Plastiques en Agriculture. 18, Place H. Bergson 75008. Paris, France.

- CSIRO. Division of irrigation research - Annual Report 1974-1975. CSIRO-Griffith NSW, Australia.

- P. DUBOIS. Manuel de Plasticulture. 95 pages. 90 F; Edition CEMP, 21, Rue Pinel, F 75013 Paris, France.

- R. FRANKEL and E. GALUN. Pollination mechanisms, reproduction and plant Breeding. 1977, 270 p. Ed. Springer Verlag, US. $ 24,60.

- V.I. GAPONENKO. Influence des facteurs externes sur le metabolisme de in chloro-. phylle (en russe). Ed. Nauka i Teknica Minsk, 1976, 241 pages.

- Cartenbauliche Versuchsberichte 1976. Landwirtschaftskammer Rheiland D 53 Bonn. FR Germany. Mit Heft 8 : Rettich und Heft 9 : Kulturtranschling. -

- G. HAENSCH and G. HABERKAMP de ANTON. Dictionnary of agriculture. Fourth Edition : german, english, french, spanish, russian with additional latin index. Ed. Elsevier Scientific ISBNO-444-99849-7-1975, 1000p. US $ 66,75.

- R. HEITEFUSS and P.H. WILLIAMS. Physiological plant pathology. 1976. 840pp. Ed. Springer Verlag, US $ 79,60.

- M. LUCKNER, L. NOVER and H. BOHM. Secondary metabolism and all differentiation. 1977, 170 p. Ed. Springer-Verlag, US $19,70.

- J.P. MIKSCHE. Modern methods in forest genetics. 1976, 288 p. Ed. Springer Verlag. US % 23,80.

- B.G. PAGE and W.T. THOMSON. The 1976 newly revised insecticide, herbicide, fungicide quick guide. Ed. Thomson publications. P.O. Box 7967, Fresno Calif. 93727, U.S.A., 180 p., $ 10,00.

- Photoperiodisme chez les animaux et les v6getaux (en russe). Edition Acad6mie des Sciences de I'U.R.S.S., Leningrad, 1976, 212 p.

- Les plastiques en agriculture. Cumptes-rendus du Colloque National,. fevrier 1976, Hyares, Var. Edition CIPA, 18, Place M. Bergson 75008 Paris, France.

- M. De RAVEL d'ESCLAPON. Les cultures florales de serres. 1976, 259 p. Commande Fianteur, 17, avenue Guillabert 06600 Antibes, France.

- J. REINERT and Y.P.S. BAJA.J. Applied and fundamental aspects of plant cell, tissue and organ culture. 1976, 830 pp. Ed. Springer Verlag, US $ 77,90.

- A.A. RIMKEVICH and N.B. KHALAMEIZER. Conti¯81e des systemes de conditionnement de Pair (en russe). Ed. Machinostroenie, Moscou, 1977.

- G. SEMENZA and E. CARAFOLI. Biochemistry of membrane transport. 1977. 740 pp. Ed. Springer Verlag, US $39,80.

- C.R. STOCKING and U. HEBER. Intracellular interactions and transport processes. 1976. 517 pp. Ed. Springer Verlag, US $ 59,50.

- A. TREBST and M. AVRON. Photosynthesis 1. Photosynthetic electron transport and photophosphorylation. 1977. 800 pp. Ed. Springer Verlag. US % 79,60.

Technical communications of ISHS. Copies can be ordered by the secretariat of the society : Bezuidenhoutseweg 73, the Hague, Netherlands.

N° 55.- IV symposium on horticulture economics. Wurzburg (RFA), September 1975. Print in august 1976, 359 pp.

N° 56.- Symposium on juvenility in woody perennials. Beltsville (USA), October-November 1975. Print in July 1976, 317 pp.

N° 57.- Ist international symposium on tropical and subtropical fruits. Lima (Peru). February 1976. Print in October 1976, 274 pp.

N° 59.- Symposium on virus diseases of ornamental plants, Noordwijkerhout (Netherlands), may 1976. Print in august 1976, 182 pp.

N° 60.- Symposium on breeding of rubus and ribes. East Mailing (UK), July 1976. Print in december 1976, 219 pp.

N° 63.- Symposium on floriculture plant breeding and genetics East Lansing (USA), August 1976. Print in december 1976, 231 pp.

N° 64.- Symposium on production of ornamental pot plants and cutflowers. AAS (Norway), August 1976. Print in december 1976, 249 pp.

N° 69.- Symposium on pears, Florence (Italy), October 1976. Print in January 1977.

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XX. ARTICLES SIGNALES
ARTICLES IN PRINT

E.J. FORTANIER and JONKERS. Juvenility and maturity of plants as influenced by their ontogenetical and physiological ageing. (Acta Hort., 56, 1976 : 37-44).

0.M. HEIDE and al. Seed germination and bolting in red beet as affected by parent plant environment. (Physiol. Plant, 1976, 36 : 343-349).

H. JONKERS. Effect van gibberelline-bespuitingen op de jeugdperiode van appel-zaailingen. (Landbouwk. Tijdschr., 1975, 87 : 330-333).

O. JUNTTILA. Seed germination and viability in five Salix species.(Astarte, 1976, 9 : 19-24.

W.J. UNDER and H. JONKERS. Gibberellin promotion of physiological leaf spot in detached' golden delicious ' apple leaves. (Neth. J. Agric. Sci., 1975, 23 : 126-130).

W.J. KENDER and H. JONKERS. Hormonal regulation of physiological leaf spot and primature leaf abscission in 'golden delicious' apple trees. (Scientia Hort., 1975, 3 : 285-292).

H.G. KRGNENBERG. Flower induction in perpetual kale (Brassica oleracea var. ramosa DC). (Neth. J. Agric. Sci., 1976, 24 (1) : 58-66).

R.L.M. PIERIK. Relative dormancy in excised vegetative buds of Rhododendron. (Neth. J. Agric. Sci., 1976, 24 : 98-104).

R.L.M. PIERIK. Vegetative propagation of horticultural crops in vitro with special attention to shrubs and trees. (Acta Hort., 1975, 54 : 71-82).

R.L.M. PIERIK. Anthurium andraeanum plantlets produced from callus tissues cultivated in vitro. (Physiol. Plant., 1976, 37 : 80-82).

R.L.M. PIERIK and H.H.M. STEEGMANS. Vegetative propagation of Anthurium scherzerianum Schott through callus cultures. (Scientia Hort., 1976, 4 : 291-292).

R.L.M. PIERIK and H.H.M. STEEGMANS. Freesia plantlets from flower-buds cultivated in vitro. (Neth. J. Agric. Sci., 1975, 23 : 334-337).

J. Van BRACT and K.J. Van AST. Substitution of cold requirements of tulip CV 'apeldoorn ' by GA3. (Scientia Hort., 1976, 4 : 117-122).

J. Van BRAGT, H. Van GELDER and R.L.M. PIERIK. Rooting of shoot cuttings of ornamental shrubs after immersion in auxin-containing solutions. (Scientia Hort., 1976, 4 : 91-94).

S.J. WELLENSIEK. The influence of photoperiod and of GA3 on flower development and stem elongation of Silene armeria L. (Proc. Kon. Ned. Akad. Wet. C, 1976, 79 : 84-89).

S.J. WELLENSIEK. Stem elongation of 'Dwarf' Silene armeria L. as influenced by generative condition and GA3. (Proc. Kon. Ned. Akad. Wet. C, 1976, 79 : 90-94).

S.J. WELLENSIEK. The direct action of the flower hormone in Silene armeria L. (Z. Pflanzenphysiol. Band., 1976, 79 : 210-217).

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

1977. May 16-18. Nantes, France
International Congress on Camelia
Inquiries : Organising Committee. 3 Place de la Petite Hollande, B.F. 237 44000 - Nantes, France.

1977. Mai 16-18. Strasbourg, France
Rencontre annuelle de la Societe Francaise des Thermiciens sur le theme : Energetique et thermique de l'homme dans son environnement.
Renseignements : Secretariat Rencontre SFT-Centre d'Etudes Bioclimatiques du C.N.R.S., 21, rue Becquerel, F.67087 Strasbourg, France.

1977. May 18-20. London (U.K.)
Chelsea flower show.
Inquiries : R.H.S., Vincent Square London SWIP2PE (U.K.).

1977. May 25-27. Florence (Italy)
Ilird European Light Congress.
Inquiries : Centro Internazionale dei Congressi, Largo Pratello Orsini 1, Firenze, Italy.

1977. Mai 27-30. Tregourez, France
IIIe Floralies de Cornouailles.
Renseignements : Societe Nationale d'Horticulture de France, 84, rue de Grenelle, 75007 Paris, France.

1977. May 31. London (U.K.)
Conference on plastics and hydroponics.
Inquiries : BAHPA, 47 Piccadilly, London WIVODN (U.K.).

1977. Juin. Pushchino (U.R.S.S.)
Conferences (3jours) : Utilisation de la photosynthese comme source d'energie.
Renseignements : Commission d'Etude Ac. Sc. U.R.S.S. Centre de recherche de Biologie. Pushchino, Region de Moscou 142292, U.R.S.S.

1977. June 21-25. Moscow, U.S.S.R.
World Electrotechnical Congress WELC.
Inquiries : Organizing Committee of WELC, Kalinina prospect, 19 Moscow G 19, U.S.S.R.

1977. Juin 21-30. Krasnojarsk (U.R.S.S.)
Ecole d'ete : Bases biochimiques et biophysiques de regulation de la biosynthese.
Renseignements : Commission d'Etude Ac. Sc. U.R.S.S. - Centre de recherche de Biologie, Pushchino, Region de Moscou 142292, U.R.S.S.

1977. June 27- July 7. Leipzig, FR Germany
4th Scientific Congress of agriculture tropical institut.
Inquiries : Agricultural Tropical Institute, Fichtestrasse 28, Leipzig 703, FR Germany.

1977. July 4-8. Yerevan, U.S.S.R.
VI International Symposium on apricot culture and decline.
Inquiries : General Department of Horticulture - Ministry of Agriculture. Orlikov 1/11-107139, Moscow 1-139, U.S.S.R.

1977. July 4-9. Halle-Saale (GDR)
International conference on regulation of development processes in plants.
Sections : 1-protein pattern and regulation of differentiation. 2-regulation of organelle biogenesis.
3-regulation of differentiation in cell and tissue cultures.
4-regulation of development by interactions of plant hormones or other substances.
Inquiries : Secretariat of Conference. c/o Institute of Plant Biochemistry of Ac. Sc. of GDR, P.O. Box 250 DDR, 401 Halle-Saale-German Democratic Republic.

1977. July 5-8. Montfavet-Avignon, France
IIIrd Eucarpia Meeting on Penner.
Inquiries : Mr. E. POCHARD, Capsicum Eucarpia Meeting. I.N.R.A. Domaine Saint-Maurice, 84140 Montfavet-Avignon, France.

1977. July 11-13. Munchen (RFA)
IIIrd International Meeting on Grass and lawns.
Inquiries : Deutsche Rasengesellschaft c/o Institut fur Planzenbau, 5300 Bonn 1, Katzenburgweg 5 (RFA).

1977. July 18-23. Wellesbourne (U.K.)
ISHS Symposium on Timing of Field Production of Vegetables.
Inquiries : Dr. GRAY, Nat. Vegetable Research Station. Wellesbourne Warwick CV35 9EF, U.K.

1977. July 25-30. Nyon, Switzerland
XVth International Congress on Vine and Wine (0I.V.).
Inquiries : P. MAROU, Office International de la Vigne et du Vin. 11, rue Roquepine, 75008 Paris, France.

1977. July 27 - August 3. Munchen (FRG)
Ist Symposium on Spices and Medicinal Plants (ISHS).
Inquiries : Dr. C. FRANS, Technical University of Munich, Lehrstuhl fur Gemusebak der TU Munchen D-8050, Freising, Weihenstephan, FRG.

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 S. 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. Congress 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 (U.R.S.S.)
Symposium : Cinetique et thermodynamique des processus intermediaires dans les systemes biologiques.
Renseignements : Commission d'Etude Ac. Sc. U.R.S.S., Centre de recherche
de Biologie, Pushchino, Region de Moscou 142292, U.R.S.S.

1977. September (The Netherlands)
Symposium on Vegetable irrigation.
Inquiries : Prof. H.D. HARTMANN, Inst. f. Gemusebau,
6222 Geisenheim/Rh, FRG.

1977. September 1-14, Bet Dagen (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.
Topics : Methodology of data collection-transfer and analysis-biometrical reference intervals-endocrinology-cell biology-shiftwork-chrono-pharmacology-cancer-nutrition-education-agriculture.
Inquiries : Secretary Office, ISC XIII Conference, P.O. Box 1071 20100,
Milano, Italia.

1977. September 4-9. Reading (U.K.)
4th International Congress on Photosynthesis.
Serie I : Light reactions ; lightharvesting and reaction centres. Organization of electron transport ; Photosystem H and 02 evolution ; Phosphoryl-ation and ion transport ; special session on plastocyanin.
Serie II : Dark reactions : Photosynthesis in cells and tissues ; Photosynthesis and productivity ; carbon metabolism ; regulation of metabolism ; development of photosynthetic systems.

Serie III : Applied aspects : solar energy conversion in biology ; photo-synthesis and food.
Inquiries : Prof. D.O. HALL, University of London, King's College, 68 Half Moon Lane London SE24, U.K.

1977. September 4-10. Tokyo (Japan)
26th International Congress of pure and applied Chemistry.
Inquiries : 26th Congress of IUPAC, P.O. Box 56, Kande Post Office, Tokyo 101-91, 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.
Topics : 1. Physical and physiological factors in rooting. 2. Chemical aids to vegetative propagation. 3. Use of plastics in propagation. 4. Container-grown-stock compost and nutrition. 5. Mechanisation. 6. Preservation in cold storage.
Inquiries : J.C. KELLY, Kinsealy Research Centre, Malahide Road, Dublin, Ireland.

1977. Septembre 12-30. Paris (France)
Microbiologie du sol et des eaux, cycle de formation continue.
Renseignements : ADEPRINA, 16, rue Claude Bernard, 75231'Paris C6dex 05, France.

1977. Septembre 14-17. Nice (France)
3e Congre's mondial Interflora et Florexpo.
Renseignements : Federation 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. H. JONKERS, Dept. of Horticulture, Agricultural University, P.O. Box 3, Wageningen 6140, The Netherlands.

1977. September 19-22. Dublin (Ireland)
ISHS Symposium on production of protected crops in peat and other media.
Topics : 1. Physical and chemical properties of peat and other substrates. 2. Materials for potting composts. 3. Analysis of sushstrates.

4. Macro and microelement nutrition, slow release fertilizers. 5. Disease control, sterilisation and re-cycling of substrates. 6. Complete cultivation of crops in peat and other media including nutrient solution. 7. Irrigation of the growing medium including use of capillary matting.
Inquiries : M.J. MAHER, Kinsealy Research Centre, Malahide Road, Dublin 5, Ireland.

1977. September 27-30. Nottingham (U.K.)
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, U.K.

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

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

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

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, University of Khartoum, Shambat. The Sudan.

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. I.N.R.A. Bordeaux, 33140, Pont de la Maye, France.

1978. July 24-28. Zurich (Switzerland)
4th Int. Congress of Pesticide Chemistry
Inquiries : Secretariat P.O. 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 Bundesznstalt Messeweg 11/12 D.3300 Braumschweig FR Germany.

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

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

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

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

1979. 6 mois Bundesgartenschau BONN (FRG)

1980. Avril Gand (Belgique)
Floralies gantoises.

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

1981. Avril. Genes (Italie)
Euroflora.

1982. 6 Months Floriades des Pays-Ras.

1982. Hambourg (FRG)
21st International Horticultural Congress.
Inquiries : Prof. D. FRITZ, Institut fur Gemusebau 8050 Weihenstephan-Freising/O0B, 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