IMPERIAL BOTANICAL CONFERENCE

LONDON JULY 7–16, 1924

President: SIR DAVID PRAIN, C.M.G., C.I.E., F.R.S.

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Hon. Secretary

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FOREWORD

By SIR DAVID PRAIN, C.M.G., C.I.E., F.R.S.

PRESIDENT

A DECADE ago an event in European history prevented botanists throughout the globe from carrying into effect a resolution they had formulated five years earlier. Finding themselves, five years later, no longer empowered to comply with the letter of that international resolution, representatives of botany in this country decided that they would, if possible, fulfil its spirit. The steps taken and the results attained are recorded in the Report now published of the proceedings of the Imperial Botanical Conference held in London in 1924.

While the proceedings recorded here were in progress, the hope became general that this Conference might prove to be but the first of a series of similar reunions of botanists at work in the various Dominions and dependencies of the Empire. The feeling was entertained that the permanent record, in an accessible form, of the proceedings of this first Conference, might serve as a means to the end desired. At the close of the Conference, those botanists who had undertaken the tasks of organising its convocation and arranging its deliberations were accordingly requested by their colleagues to consider, before demitting office, the feasibility of editing and publishing an account of its proceedings. This request has received the careful consideration of the Executive Committee and, as a result, it has been found possible to prepare a Report which, it is hoped, may meet the wishes of those who took part in the Imperial Botanical Conference of 1924.

LONDON
1 *November*, 1924

PRESIDENTIAL ADDRESS AND OPENING OF CONFERENCE

By SIR DAVID PRAIN, C.M.G., C.I.E., F.R.S.

Ladies and Gentlemen,

I have a pleasant duty to perform this morning. On behalf and in the name of the Executive Committee that has organised this Conference I have to welcome all the botanists who are here to-day. I have also, on behalf of the botanists of this country, to thank those botanists from our overseas possessions who, by their attendance, have made this Conference Imperial in fact as well as in name. I feel too that I may, on behalf of all here, welcome those foreign botanists whose interest in our proceedings has induced them to honour us by being with us as our guests.

I have been asked oftener than once to explain how and why this Conference has come to be summoned. Many here know; some do not. It may therefore be of use if the circumstances be reviewed: some of the things that have happened may have a bearing on some of the conclusions to be reached when we assemble again in this room at noon on 12th July.

In 1900 a quinquennial International Botanical Congress met in Paris. An official invitation from Austria was then received and accepted; the ensuing Congress was therefore held in Vienna in 1905. At the Vienna Congress it was a general wish that the next Congress should take place in London in 1910. The British botanists present at Vienna had come unprovided with official authority to tender the necessary invitation. They were unable to obtain the requisite authority before the Congress of 1905 was over, and, as a consequence, the Congress of 1910 met in Brussels. British representatives at the Brussels Congress took with them official authority to invite the International Congress to meet in London in 1915. This invitation was accepted and after the Brussels Congress was over, an Organising Committee was duly appointed in this country to take over charge from the Belgian Organising Committee. Ten years ago today everything save minor details had been arranged by the British Organising Committee for the London Congress due in 1915.

In the beginning of August, 1914, events over which the British Committee had no control, affected international relationships so adversely that the International Botanical Congress due to meet in London in 1915 could not be held. The constitution of these quinquennial Congresses made provision for such a contingency. It had been prescribed in advance that if, for whatever reason, a duly constituted Organising Committee should be prevented from holding its particular Congress, the duty of summoning the next Congress must devolve upon the Association Internationale des Botanistes. When it was announced that the International Botanical Congress due in London in 1915 must be abandoned, the British Organising Committee were reminded by the Association Internationale des Botanistes what the terms of the constitution of these International Congresses are.

The British Organising Committee recognised the right of the Association Internationale to summon the next Congress. But, until a new Organising Committee had been duly appointed it was the duty of the British Committee to remain in being. The Association Internationale had not felt the effects of war when it intimated to the British Organising Committee in 1916 its intention to arrange for an International Botanical Congress in 1920. But in 1919 the Association Internationale was so seriously affected by the blessings of peace that its own continued existence had become precarious; it was no longer in a position to arrange for an International Botanical Congress. A new situation had been created. The Association which alone had authority to initiate an International Botanical Congress was unable to do this: the Organising Committee which might have been able to summon an International Botanical Congress had no authority to do this. Having considered this new situation, the British Organising Committee decided to convene, if possible, a Botanical Conference which should be Imperial instead of International.

The possibility of summoning an Imperial Botanical Conference depended on two considerations. The first question to be considered was that of the funds in the custody of the Organising Committee. These funds had been contributed by subscribers in order to meet expenses to be incurred in connection with the International Botanical Congress proposed to be held in 1915. Having been subscribed for a definite purpose they could not be used by the Organising Committee for a different purpose. Individual subscribers to the International Botanical Congress fund had therefore to be asked whether they desired their subscriptions to be returned or if they could agree to their subscriptions being used to meet expenses to be incurred in connection with an Imperial Botanical Conference. The response to this enquiry was extremely gratifying and it is largely owing to this fact that we are here to-day.

When it was clear that the Organising Committee could, without impropriety, use the funds subscribed on account of an International Congress in meeting the expenses of an Imperial Conference, it became possible to investigate the further consideration whether the attendance of botanists from overseas could be hoped for. Individual botanists resident in our various dominions and dependencies were therefore asked to say whether, in the event of such a Conference being summoned, they would be able to be present. The response to this second enquiry proved as gratifying as the response to the former one. The replies however were so often coupled with a suggestion and, indeed, a hope that the Conference be deferred until the British Empire Exhibition should take place, that it was decided that the Exhibition year should be also the year of this Imperial Conference.

During the final phase of their work the members of the Organising Committee benefited by welcome and unlooked for help. That Committee was appointed immediately after the Brussels Congress of 1910. Since then a new and vigorous generation of botanical workers has grown up. The idea that had been explored by the Organising Committee in 1920, suggested itself independently to active members of the younger generation, and at the meeting of the British Association held at Hull a Committee was appointed to consider the possibility of holding an Imperial Botanical Conference in 1924. The new Committee came into touch with the older Committee, and the Executive Committee, which has drawn up the programme for this Conference and in whose name it is my privilege to bid you welcome now, came into existence through the amalgamation of the two bodies.

I am glad to be able to add, by way of completing this history, that the British Organising Committee, which came into existence in 1910, has at last been freed from its responsibilities. Recently the welcome information has reached this country that a Committee has been constituted to organise an International Botanical Congress to be held in the near future in the United States of America.

I should like now to invite your attention to a collection of interesting exhibits which has been displayed for inspection in the rooms of the Botany Department of this College. These exhibits will repay examination and I venture to suggest that we now adjourn so as to have an opportunity of seeing them and, at the same time, of renewing old and forming new acquaintanceships. From this afternoon onwards you will find the programme before you a full one. You are not only to be kept busy all day and every day during the rest of this week; you will have, during much of the time, to consider that insoluble problem—the possibility of being in two places at once.

I now declare this Conference open.

During the Conference the Acting Agent-General for Victoria conveyed his best wishes for the success of the Conference and delivered a message from the Government of Victoria that the latter was willing to co-operate in any technical directions the Conference might advise.

During the discussion on "The Best Means of Promoting a Complete Botanical Survey of the Different Parts of the Empire" a unanimous vote of appreciation for his services to Botany was accorded to Mr J. H. Maiden, F.R.S. on the occasion of his retirement from the Directorship of the Sydney Botanic Garden, accompanied by the best wishes of all members of the Conference for continued health and prosperity during his retirement.

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CONTENTS

PLANT PHYSIOLOGY

THE PHYSIOLOGY OF CROP YIELD: A SURVEY OF MODERN METHODS OF ATTACK

(CHAIRMAN: DR F. F. BLACKMAN, F.R.S.)

Dr F. F. Blackman, F.R.S. General Introduction
(not given orally)

Crop yield has been an age-long pursuit of mankind. Striking were the achievements of agriculture before the dawn of history—tilth—irrigation—manuring—rotation of crops. With the beginning of the scientific age came fertilisers, glass houses, etc.

The modern problem is to produce the greatest yield of crop per unit area. But still it is an applied problem, not one of pure science. Its dominating limitation is that this must be done at the least possible expense.

How different would be the outlook on plant physiology were the goal, instead of the largest yield per area of natural soil, the largest possible yield from each single plant individually, and were it pursued regardless of expense! Then plant physiology might be in the favoured position of human physiology and our field of research be endowed and pushed forward in the way that falls to the lot of medical researches which aim at improving the efficiency of the individual human frame without thought of cost.

The financial setting of our problem prevents the exploitation of wholly artificial conditions of plant development and concentrates attention only on the use of semi-natural soil and semi-natural conditions of growth.

This financial limitation of research to such variable conditions introduces immense complexity and makes very difficult the task of establishing fundamental truths of wide application; but on the other hand it gives great importance to small margins of difference.

In this session our object is to bring together the different chapters of modern scientific investigation which combine to illuminate the general problem. We may distinguish five such chapters.

CHAP. I. *The experimental study of the factors and conditions affecting Growth*

Crop yield is a special case of plant growth, and underlying each special crop problem is the general physiological one of the augmentation of growth, and its control by such factors as nutriment, aeration, light and dark, temperature, CO_2-content of the air, and expense, together with other factors that may yet be brought into account such as traces of special chemical elements, the electrical setting of the plant, etc. It would have been impossible to investigate the single factors in the field, and fundamental studies have been made in the laboratory where control of factors is possible. In the field these uncontrolled factors are generally grouped as weather and left to natural variation. With intensive cultivation in glass houses, temperature and humidity are brought under human control and we get nearer to laboratory conditions. Light can now be added to the controllable factors; using modern powerful electric illuminants it is possible to supply artificial light adequate for plant growth, either continuously or discontinuously, and the study of the interaction of these "weather factors" can be pushed further in the laboratory.

The first communication, by Dr F. G. Gregory, illustrates the study of plant growth in the laboratory, with controlled artificial light; the second, by Professor V. H. Blackman, elucidates the mixed results of electro-culture in the field by laboratory studies in controlled conditions.

CHAP. II. *The Ontogeny of the Crop and the Duration of the Development Sequence*

In this chapter we stress that complexity of the whole situation which is due to the organisation of the plants we work upon. We realise that crop yield covers a wide range of special cases. The desired crop may be the fleshy parts of the whole plant or its wood, fibre or bark. On the other hand it may be some special morphological part, as the flower buds of the caper, the petals of the rose, the stamens of the crocus, the fruits of the apple, the seeds of the pea, the seed-hairs of cotton, not to mention various tubers and roots.

The desired part comes at a late stage of a long development sequence. All other parts except this one morphological unit may be valueless, and cultivation has to work upon the morphological plasticity that most plants exhibit, and endeavour to produce the maximum of the crop parts and the minimum of the antecedent or alternative parts. For the mastery of this aspect of crop yield we need detailed studies of the normal sequence of development of each crop plant combined with an exploration of its plasticity under the influence of natural and artificial variations of environment, including surgical operations such as pruning.

A further set of problems arises out of the effect on yield of varying duration of the development sequence in the individual crop plants. In most plants this sequence is not a closed one, but development of crop may be prolonged by suitable external conditions and yield thus increased. Under completely controlled laboratory conditions the development sequence of an annual plant could be carried through at the ideal rate found to give the maximum duration of the crop-yielding phase of the plant's ontogeny. In the field it is generally the weather cycle which initiates and closes the conditions for the development sequence. With unknown weather before him the agriculturist has to decide year by year when he will start the development sequence—to fix the sowing date for each crop. Ages of past experience have accumulated much empirical wisdom on this matter, and it is clear that for the purposes of crop yield it is possible to improve on the natural determination of sowing date which coincides with the end of the previous growth cycle.

This chapter will be illustrated by Dr W. L. Balls' account of his method for analysing the development of the plant by collating records of the significant stages antecedent to the final yield. An analysis of the effect of different sowing dates on the cotton crop in Egypt will be presented by the same method.

CHAP. III. *The quantitative relations of Factors and Yield*

No plant can develop except in the presence of innumerable "factors" the magnitudes of which are capable of affecting its rate of development and also its ultimate yield.

As a crude analysis these factors may be distinguished into those which concern the supply of materials of growth and those that concern the conditions of growth. Some factors, conspicuously light, act in both categories.

A line along which investigation has been pushed is to endeavour, with a series of cultures, to keep all factors but one constant and then to compare the effect, on growth and yield within the series, of varying the one selected factor over a wide range. Data for single mineral constituents of the soil of pot cultures have been accumulated and similarly experiments with varying area of natural soil for each plant to draw upon for field cultures. We are faced with the problem of relating the grades of increasing yield with the grades of increasing factor, in such series of experiments, on some empirical or rational basis.

Mr G. E. Briggs will discuss the "general law" put forward by Mitscherlich, Baule and others, as governing universally the relation between plant yield of any type and the magnitude or intensity of every outside factor, be it a mineral constituent of the soil, light or water supply.

CHAP. IV. *The complexity of the plant's Spatial Environment—Soil*

Were finance not a governing factor no doubt each crop would be grown in an ideal standardised soil, artificially prepared. As it is, a given crop cannot even be grown only in the one locality which has the nearest natural soil to the ideal. Economic reasons demand that each crop shall be grown on many natural soils.

The complexity of natural soil is enormous. We know it is a microcosm in itself with its own internal fauna and flora as well as wide variations in chemical nature and physical properties. The addition of one and the same given amount of fertiliser to two different types of soil may produce quite different reactions, directly or indirectly, when the equilibrium of the microcosm is thus disturbed. To establish whether or not small margins of favourable effect do actually occur for a given crop by shifting the existing equilibrium of the soil towards some new equilibrium requires extreme critical care in experimentation. All the experiments must be adjacent and also simultaneous, as no weather sequence during development is ever exactly repeated. Everything turns on the critical use of control plots of soil as standards. There has grown up a whole series of investigations aimed at securing the most trustworthy method of experimentation on this subject.

Mr E. J. Maskell will give an account of the methods of critical plot-culture from the point of view of experimental work at Rothamsted.

CHAP. V. *The complexity of the plant's Temporal Environment—Season*

Natural atmospheric conditions and weather lack even the element of stability that the soil possesses. With sufficient trouble and expense it would be practicable to prepare a large area of really uniform soil, but uniform seasons are here beyond our powers and our finance. Definitive studies of crop yield must range over a series of years and cannot escape the action of this immensely variable set of factors. The components of weather have a considerable independence so that the task of disentangling the effects of duration of sunshine, mean temperature, humidity, rainfall and air movement is one of great difficulty. Given a sufficient mass of data and adequate records of the components of weather we can add to the experimental method the methods of statistical analysis. At Rothamsted crops have been grown and weather recorded for the same plots for many years in succession.

Dr R. A. Fisher will show how significant relations between weather factors and yield can be computed by modern statistical methods from data of this type.

Dr F. G. Gregory. Experiments on Plant Growth with Controlled Light and Temperature

(*Abstract*)

Since plants growing under natural conditions are exposed to the action of many varied external factors, it becomes necessary for the purpose of analysing the effect of any one factor to ascertain in what manner the actions of two or more single factors combine in determining growth; to ascertain, for example, whether the effects of single factors are directly additive or more complexly related.

This can only be done in experiments under controlled conditions. A series of eight such experiments has been completed with Cucumber plants grown with continuous artificial light of two different constant intensities, with constant humidity and soil conditions, and covering a temperature range from 62° F. to 95° F.

The measures of growth studied have been the growth in area of single leaves and of total leaf surface, and the dry weight increase. From these the nett assimilation rate has been calculated. These assimilation data are unique in that the assimilating system has been allowed to develop under the same set of conditions in which the assimilation rate has been determined.

For all the experiments at the lower light intensity (approx. that of average winter sunlight) the curves of leaf surface increase were found to be of the same type, although a very marked optimum was found at 77° F. (25° C.). This temperature was found to be optimum also for assimilation rate, respiration rate, and for such morphological characters as leaf size, and date of appearance of the first foliage leaf.

At all temperatures over the range studied with lower light intensity

the relative growth in leaf area fell off in a regular manner from the beginning of growth onwards. This falling off in growth became very rapid above the optimum temperature.

To account for the detrimental factor at work three possibilities presented themselves:

(1) That continuous light was in itself harmful.

(2) That respiration was kept at a high level by the high temperatures, whereas the low light intensity limited the assimilation rate, resulting in progressive starvation.

(3) That the low light intensity exerted a detrimental effect on the plant.

Direct experiments with continuous light as compared with discontinuous showed results in favour of continuous light, thus disposing of the first suggestion.

The experiments at supra-optimal temperatures showed a steady nett assimilation rate in spite of the fact that the rate of increase in leaf area was rapidly falling. This is incompatible with the suggestion of progressive starvation and suggests that the growth rate of the leaf surface is not directly dependent on the assimilation rate. This is corroborated by the temperature coefficients of assimilation and relative leaf growth rate. The value of both coefficients was found to be 2·3 per 10° C. rise in temperature from the lowest temperature studied up to the optimum, but above this point the coefficient of assimilation rate falls off more rapidly than for relative leaf growth rate, indicating that assimilation rate does not directly control leaf growth, but that other factors also are concerned. There is some evidence, from the study of the growth of single leaves, to show that cell division is inhibited at the higher temperatures.

If the third suggestion were correct it ought to be possible to remove the detrimental factor by increasing the light intensity. This has been effected by increasing the light intensity three times. A similar state of things had been previously noted with plants growing under greenhouse conditions in the winter, and here the detrimental effect disappeared in the spring as the intensity and duration of light increased.

The interaction of the two factors light and temperature on growth may be represented by an optimum curve, and there is evidence to show that with increasing light intensity the optimum point for temperature rises towards some unknown limit.

The complexity of the whole problem is reflected in the changing morphological characters of the plants grown under the varying external conditions. Such characters include varying leaf size and shape, leaf thickness, and relative growth of leaf and stem.

Professor V. H. Blackman, F.R.S. The Electrical Conditions of Plant Growth

(Abstract)

Plants growing in the open and unscreened by taller buildings or other plants are subjected normally to an "air-earth" current which is of the order of 2×10^{-16} amp. per cm.^{2}, the current passing to the whole surface of the globe being only about 1000 amperes. Whether this minute current is a favourable factor in plant growth—as has been claimed for nearly 200 years—is still uncertain. The favourable effect, if any, cannot be very large, otherwise it would be impossible to grow plants satisfactorily in greenhouses. The question of the favourable effect of atmospheric electric currents artificially produced starts with the work of Lemström, who first carried out experiments about 50 years ago by stretching above field crops wires charged to a few thousand volts. He claimed that marked increases of yield could be obtained by this means, but his results did not carry conviction to most agriculturists. Since 1915, field experiments have been carried out with overhead installations consisting of thin wires (5–15 feet apart) placed at a height of 7 feet and charged to 50,000 volts. The current was at the rate of 0·5–1·0 milliamp. per acre for six hours a day during the growing season, the wires being in all cases charged positively. Of eighteen experiments carried out between 1915 and 1920 there were fourteen positive results and four negative ones. Of twelve experiments with spring-sown cereals ten were positive and two negative, the mean increase being of the order of 22 per cent.

Pot-culture experiments, in which the current passing through the plants is measured, have shown that increased yields both of dry weight and of grain yield can be obtained both with maize and barley using currents of the order of 10^{-9} amp. They have also shown that currents of higher intensities (10^{-7} amp.) are injurious, and that favourable results can be obtained with wires charged negatively as well as with those charged positively, and also with alternating current. Furthermore, such experiments have shown that application of the discharge for the second month only may be as effective as, or more effective than, one applied for the whole growing season; they also indicate that the effect on grain yield may be greater than that on vegetative growth.

Laboratory experiments have been undertaken in which barley seedlings have been subjected to the discharge from an electrified point at a potential of a few thousand volts, the current passing through the