HORMONAL CONTROL OF PLANT GROWTH

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FOREWORD

In 1947, the Uttar Pradesh Government, largely on the initiative of Dr. Sampurnanand, then Education Minister, set up a Scientific Research Committee, U.P., for the promotion of the scientific research within the State. Since then, on the recommendations of the Committee, Government have been financing a number of research projects in the fields of fundamental and applied sciences at the Universities, as well as at some non-university institutions in the State.

In spite of limited finances, this pioneering idea has paid ample dividends in keeping alive a spirit of enquiry and investigation in new frontiers of knowledge and in training research personnel who are now helping in the Second and Third Five-Year Plan developments in the State and outside it.

In 1959, the reconstituted Scientific Research Committee decided at a meeting, in which Dr. Sampurnanand, Chief Minister, was present, that time had come when a consolidated account of the progress achieved by the Committee could be published for general information and for the benefit of those who are engaged in similar fields of endeavour in other parts of India. Accordingly, a series of monographs written by specialists in their respective fields have been prepared and are being published. It is to be hoped that this effort will be welcomed on all hands and will prove useful to readers.

Chhattar Manzil Palace,
Lucknow.
May 19, 1960.

B. MUKERJI,
Chairman,
Scientific Research Committee,
Uttar Pradesh

PREFACE TO THE SECOND EDITION

The favourable response accorded to this handy monograph, has led to the demand of an early edition. I have taken advantage of this opportunity to revise the subject matter in numerous minor points. A new chapter on "Hormonal Control of Sexuality" has been added and an index has been incorporated. These changes, I hope, will increase the utility of this monograph.

Allahabad
October, 1963

N. S. PARIHAR

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INTRODUCTION

CHAPTER I

INTRODUCTION

Since very early times the mysterious forces that control the growth and development of plants have engaged the attention of botanists in general and plant physiologists in particular. For a long time it was thought that a plant growing under adequate environmental conditions only required balanced nutrients for its proper growth and development. However, during recent years it has come to be generally recognized that plant growth is dependent not only on the intake of inorganic substances through the roots from the environment, or even on the organic metabolites which it is able to synthesize, e.g., carbohydrates, proteins etc., but is in addition controlled and coordinated by certain other specific organic substances produced by the plant itself. These specific chemical substances produced by an organ or tissue may reach all parts of the organism and in very minute amounts markedly influence the function of other organs. Thus these substances have specific roles as agents for the coordination of the growth of one part with the growth of other, and they play an important part in the integration of plant behaviour. Such substances are entitled to be called plant growth hormones or simply plant hormones.

The word 'hormone' etymologically means "I arouse to activity" and was proposed by Hardy and first applied in animal physiology by Bayliss and Starling (1904) to designate the 'chemical messengers' which are secreted in the blood by one organ to stimulate the function of other.

Animal hormones have now been studied for more than 50 years and thirty or more of these have so far been identified and their chemical and physiological properties have been studied in great detail. In the case of higher animals the balance and integration among the bewilderingly complex chemical processes of different tissues are in a great measure controlled by these hormones. It will not be an exaggeration if we say that physically, mentally, sexually and emotionally we are largely the products of our hormones.

A plant is also an association of different tissues and organs which require the same kind of coordination as we have seen to be necessary in higher animals. This is achieved by the plant hormones which are not produced in special glands as in the case of animals, but in buds and certain other growing points. At every stage in the life of higher plants, right from the fertilization of the egg through all the phenomena of vegetative and reproductive development, these hormones play a dominating, and often a controlling role. The division, elongation and differentiation of cells, the formation of root primordia on shoots, the response of roots and shoots to light and gravity, the formation of leaves, the initiation of flowers, the growth and development of fruit, all appear to be directly or indirectly controlled or promoted by these hormones.

One of the typical example of a plant hormone is the organic compound indoleacetic acid (IAA) which is known to occur widely in the tissues of higher plants. It controls many of the morphological, histological and physiological changes which have been enumerated above. In the intact plant this compound is synthesized in particular hormone-producing centres, such as the terminal

bud and the young leaves. From here this substance moves down the shoot, by an active transport process which is neither diffusion nor mass flow but depends on metabolism, where it controls such aspects of growth as cell division and cell elongation. Indoleacetic acid thus can be called a plant hormone, a substance produced in one tissue and translocated in small amounts to other tissues where it influences special physiological processes.

Nomenclature. Botanists have used a number of terms more or less synonymously with the word hormone—growth substances, growth regulators, growth hormones, phytohormones, auxins, formative substances—with the result that there has arisen a confusion in the use of these terms. Recognizing this overlapping terminology, redefinitions have been suggested by Thimann (1948, 1952 a) and others. Thimann defines phytohormone (plant hormone) as : "An organic substance produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production, and active in minute amounts." This definition includes those auxins which are of natural occurrence, certain vitamins of the B complex, and other hormones such as those stimulating wound growth (wound hormones), postulated hormones of flowering and the reproductive regulators in the Thallophyta.

There are a large number of synthetic organic compounds which when applied to the plants bring about responses that are qualitatively indistinguishable from those of naturally occurring hormones, and thus simulate the effects of the native plant hormones. It has been suggested that the requirement for natural occurrence be omitted, thereby including under the phytohormones the synthetic substances found to have growth effects on

plants. Agreeing with this suggestion the term phytohormone (plant hormone) will be used in the present discussion in a broad sense to cover both natural and synthetic compounds which induce the well-known hormone-like responses when applied to plants.

GROWTH OF THE HORMONE CONCEPT

CHAPTER II

GROWTH OF THE HORMONE CONCEPT

(A) Discovery

The discovery of hormone system in plants culminating in their isolation and chemical identification forms an interesting chapter in the botanical research which began in 1881 with Darwin's experiments on phototropic responses of plants.

Darwin (1881) observed that when the coleoptiles (a cylindrical sheath surrounding the first leaves of grasses and cereals) of *Phalaris canariensis* (cannary grass) and *Avena sativa* (oat) were unilaterally illuminated, a strong positive phototropic curvature resulted. It was further found that the influence responsible for the curvature actually originates by this one-sided illumination of only the coleoptile tip and from there travels downwards. When the tip of the coleoptile was shaded by a tinfoil cap, or was removed, the phototropic curvature did not result. From these and many other experiments Darwin concluded, "that when seedlings are freely exposed to lateral light, some influence is transmitted from the upper to the lower part, causing the latter to bend." Darwin, however, did not recognize the influence as being of a concrete chemical substance transported through the intervening tissue. Whereas Darwin came upon the idea of correlation between different parts of a plant through investigations on tropic curvatures, Sachs (1865, 1882, 1887, 1898) hit upon the existence of 'chemical messengers' through his studies of flowering behaviour of begonias and squashes, and the rooting response of cuttings. Sachs

invisaged the existence of minute amounts of various organ forming (root-forming, flower-forming, etc.) substances moving in various polar patterns through the plant and controlling form and development. He put forward the idea that development of different organs by plants was the result of local concentration of these specific organ-forming substances. For example, the root-forming substances would be formed in the leaves, and would move towards the base of the stem. If the twig was ringed there will be an obstacle for further downward movement, and roots would be formed above the ringed portion, on account of the concentration of the root-forming substance at that point. Much earlier Duhamel du Monceau (1758) also supposed the effect of one organ's growth upon that of another to be due to sap streams moving in opposite directions. The first efforts to determine the chemical nature of plant growth stimulators were made by Fitting (1909, 1910). He extracted a water soluble, heat stable substance from orchid pollen which could initiate the swelling of ovaries and other phenomenon of post-fertilization in a manner suggestive of the fruit set. He thus showed the existence of a hormone-like compound in the plant tissue and at the same time proved that it could be handled outside the plant body like any other chemical substance. However, the beginning of the chemical substance idea with proof to support goes back to 1907, when Boysen Jensen began his classic experiments on the process of stimulus conduction in the *Avena* coleoptile. Boysen Jensen (1910, 1911) showed that when an excised coleoptile tip was replaced with a layer of gelatin (non-living matter) inserted between it and the stump, phototropic curvature resulted after unilateral illumination of the tip, as in normal coleoptiles.