A tentative suggestion on the evolutionary trend in the root apical structures in members of the *Scitaminales*

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Contents

1. Introduction

A perusal of the literature on root apical organization reveals that there have been very few opinions offered about any phylogenetic trend in the different structural types of apical organization. The only ones which have come to the notice of the author are by Haberlandt 1914 and recently, by Voronin 1956 (quoted by Esau 1960). While studying the root apical organization of members of *Musaceae, Zingiberaceae, Cannaceae* and *Marantaceae* of the order *Scitaminales* (Pillai & Pillai 1961 a, b, c; Pillai & al. 1961), a phylogenetic line of advance has suggested itself. The author is aware that phylogenetic conclusions in general are speculative and hence the suggestion is put forward only tentatively. Before proceeding to explain this line, it may be relevent to recapitulate the salient features in the structural organization met with in the root apices of these plants.

2. Types of structural organization

In *Musaceae* there is a common group of structural initials at the centre of which could be distinguished one or two prominent cells with a group of a few cells around it, named the "central group" (Pillai & Pillai 1961a). The initials for the different zones of the root apex arise from around this common group of initials (Fig. 1). In most of the members of *Zingiberaceae, Cannaceae* and *Marantaceae*, there are discrete initials for the plerome and root cap and a single tier of common initials for the epider-

mis and cortex, called the protoderm-periblem complex (Fig. 2; PILLAI & PILLAI 1961 b, c; PILLAI & al. 1961), though some members of the *Zingiberaceae* like *Zingiber officinale* have common initials for all the zones.

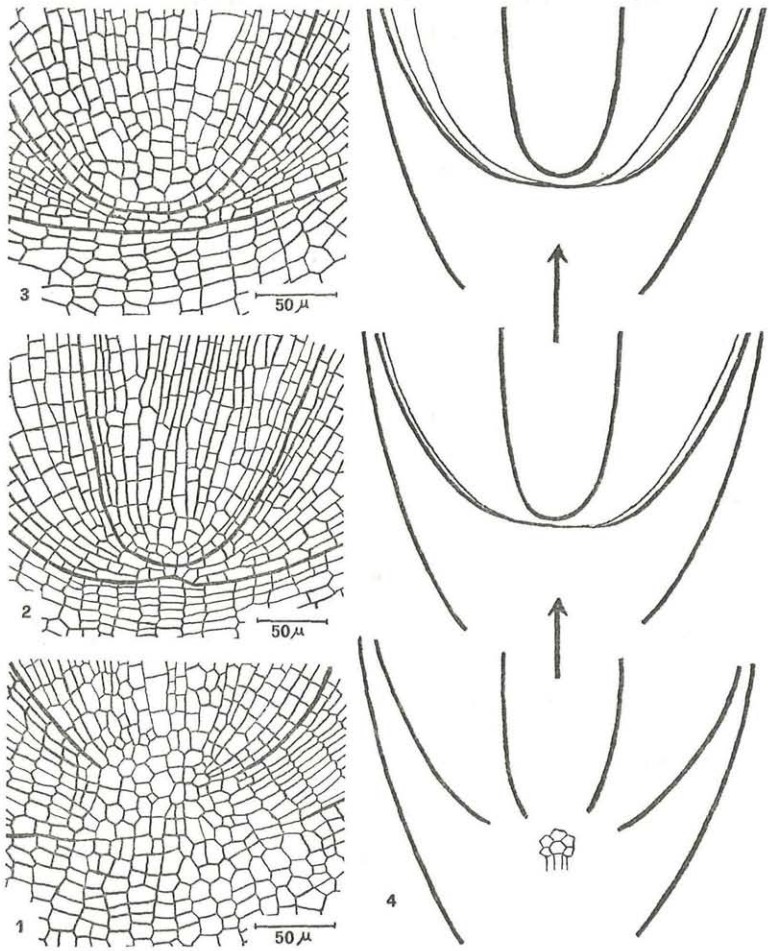

Fig. 1. *Musa sapientum*. Median longisection of the root apical region showing the common group of initials from which the different histogens separate. (Scale = 50 μ). — Fig. 2. *Costus speciosus* (*Zingiberaceae*). Median L. S. of root apex. Note the discrete plerome and root cap initials with the protoderm-periblem complex of one tier between them. (Scale = 50 μ). — Fig. 3. *Maranta arundinacea*. Median L. S. of root apex. Note the discrete plerome and root cap initials with two tiers of protoderm-periblem complex, of which the outer, the dermato-hypodermis complex, gives rise to the dermatogen and hypodermis only. (Scale = 50 μ). — Fig. 4. The evolutionary trend in the root apical structures of members of *Scitaminales*.

In *Maranta arundinacea* the root apex shows further specialisation, there being discrete initials for the plerome, the root cap, and a protoderm-periblem complex of two tiers (Fig. 3). The outer of these tiers, the dermato-hypodermis complex (PILLAI & PILLAI 1961 c), is concerned with the formation of the dermatogen and hypodermis only, while the inner tier gives rise to the rest of the cortex.

3. HABERLANDT's view

HABERLANDT 1914 has put forward a scheme based on the types of root cap formation. According to this, the most primitive type is one where the root cap arises from a special meristematic layer, the calyptrogen. The next in the line is the type where the dermocalyptrogen occurs. The third step is where the protoderm and the outer cortical layers also contribute to the cap. The point of origin of the cap becomes more and more deep-seated in the more advanced types, ultimately reaching a climax where the meristem of the root cap and root proper coalesce to form a common meristem.

"If the first of these six types be ignored for the moment, and the remaining are considered in succession, a sort of panoramic view may be obtained of the changes which the root tip of phanerogams has undergone during the gradual evolution of a cap or hood for the protection of primordial meristem. In the simplest case, the desired result is achieved by means of a proliferation of the protoderm (Type 2). A more serious modification of structure is produced where this hypertrophy extends to the cortical layers (Types 3 and 4). The influence of the root cap thus tends to affect the more and more deeply situated tissues of the root. The organic and genetic connection between the parent organ and appendages is most intimate where an initial zone common to the two is developed (Types 5 and 6)" (HABERLANDT 1914: 89—92).

According to this view, therefore, the root apex with common initials for all the zones is considered the most advanced. HABERLANDT 1914: 714—715 says "For phylogenetic reasons the presence of several apical cells is probably always to be regarded as a derived condition among phanerogams. We are forced to conclude that the primordial meristem with several apical cells is secondarily derived from that with a single initial cell so far as phanerogams are concerned."

GUTTENBERG 1960 has criticised the classification of root apical structures into types by the older authors as not correct because they had investigated different categories of roots like the primary, secondary and lateral on the one hand, and on the other, roots of different ages. These, according to GUTTENBERG, differ in their apical structure and so cannot be compared and correlated. He points out that these authors have overlooked the great differences in structure which exist between the embryonal and

growing root apices. He has broadly classified the root apical structures into

(1) the closed type, where the histogens for the various tissues are discrete and remain so from the embryonal stages till the roots become mature, and

(2) the open type, where all the tissues arise around an unspecialized, common group of initials.

He has also pointed out that a closed type may change during histogenesis and development from the embryo to the mature condition and give place to an open one. GUTTENBERG mentions no further change in the apical organization once the root becomes mature. PILLAI & PILLAI 1961a, b, c and PILLAI & al. 1961 have studied only the apices of mature roots. Moreover, the author has not been able to substantiate GUTTENBERG's view regarding differences in the apical organization between main and lateral roots in *Scitaminales*. So, it may be concluded that once the structural organization at the apex has become stabilized, there is no further change. The evolutionary trend in such roots is being discussed here.

4. Suggested phylogenetic line

From the investigations on the members of the *Scitaminales*, a different line of advance from that of HABERLANDT 1914 is suggested. On the basis of morphologic and other characters, taxonomists like HUTCHINSON 1934 and LAWRENCE 1951 consider *Musaceae* to be primitive and *Marantaceae* to be the most advanced among the four families of *Scitaminales*. Also, it is an accepted maxim that advance is usually from the indefinite to the definite, unlimited to the limited and unspecialized to the specialized. In the four members of *Musaceae* which were investigated, there is a common group of initials for all the meristems. In most of the members of *Zingiberaceae*, *Cannaceae* and *Marantaceae*, the apical organization advances to the formation of three independent zones, one each for the plerome and root cap, and a third, the protoderm-periblem complex. Some members of *Zingiberaceae* like *Zingiber officinale*, with common initials for all, may be considered as connecting links between these two. After this second step, the line advances and culminates in the structural organization met with in *Maranta arundinacea*, where the protoderm-periblem complex shows further specialization. It is two tiered, the inner being concerned with the production of the cortex, while the outer tier gives rise to the dermatogen and hypodermis. This scheme is similar in its essentials to the one proposed by VORONIN 1956.

This idea derives support, though not conclusively, from the organization met with in the root apices of some members of *Palmaceae* (PILLAI & PILLAI 1961d). It is accepted that in a predominantly arborescent family, the climbing habit is more advanced. Judged by this, *Calamus rotang*

among the *Palmaceae*, is more advanced than the arborescent members like *Cocos nucifera* and *Areca lutescens*. This is corroborated by their root apical structures also, the former having discrete initials whereas the latter have common initials at their root tips.

The most common structural configuration met with in members of *Palmaceae* shows, according to GUTTENBERG 1941, a close resemblance to that at the root apices of gymnosperms. According to this, the organization at the root apices of palms like *Cocos nucifera* is less evolved.

The work of MULAY & PANIKKAR 1956 and MULAY & al. 1959 afford further support, where they find a common group of initials in the root apices of terrestrial orchids and discrete initials in those of the more advanced epiphytic ones.

Such a line of advance in these plants correlates with the other characters basing on which their primitive or advanced nature has been postulated. In this connection, EAMES & MACDANIELS 1947 say "Evolutionary progress has perhaps been from a single centre of growth to a group of three or four centres, with progressive increase in independence of zones." This line of advance is shown in fig. 4.

5. Summary

A tentative suggestion is made regarding the evolutionary trend in the root apical structures of members of the order *Scitaminales*. The most primitive root apical structure is met with in the root apices of members of *Musaceae* which exhibit a common group of initials for all the tissues. The next stage is exhibited by the root apices of members of *Zingiberaceae*, *Cannaceae* and *Marantaceae* showing specialization of function. They possess discrete initials for the stele and root cap and a single tier of common initials for the epidermis and cortex — the protoderm-periblem complex. Some members of the *Zingiberaceae* like *Zingiber officinale* having common initials for all tissues maybe the connecting links. This trend reaches its culmination in the root apex of *Maranta arundinacea* which has discrete initials for the stele, the root cap and a two-tiered protoderm-periblem complex, of which the outer, the dermato-hypodermis complex, gives rise to the dermatogen and hypodermis and the inner to the rest of the cortex.

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