Phyton (Austria)	Vol. 15	Fasc. 1—2	155—163	30. 8. 1973

Observations on the morphology and anatomy of floral appendages showing phyllody in *Sesamum mulayanum*

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1. Introduction

Phyllody, a disease recognized by the transformation of the floral parts into green, leafy structures, has been reported in some species of *Sesamum* such as *S. orientale*, *S. orientale* × *prostratum* and *S. radiatum*. The causal factor of this phenomenon has been disputed (KASHIRAM 1930, PAL & PUSHKARNATH 1935, RHINO & al. 1937, VASUDEVA & SAHAMBI 1955, CHOOPANYA 1971). In the present report our observations on phyllody in *S. mulayanum* NAIR have been recorded. Unlike the previous works

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where emphasis has been on the pathological aspects, our attempt has been to make a detailed survey of the anatomical changes taking place in the organs exhibiting the phenomenon.

2. Material and Methods

Sesamum mulayanum is a wild annual herb growing abundantly on the Old Delhi Ridge during rainy season. The growth of these plants was normal when they were transplanted on to a bed in the University Botanical Garden. The first appearance of the disease was noticed within a month of transplantation. However, the virulence was at its peak in the last week of September, 1971. It must be mentioned that only 10 per cent of the plants transplanted exhibited phyllody.

For anatomical studies the flowers at the fifth node from the top were chosen as in all the cases, this node indicated transformation of all its floral appendages into leaf-like structures.

Three different schedules were followed to obtain preparations suitable for observations. (a) The various floral appendages were cleared with chloral hydrate technique after the procedure outlined by PALIWAL & KAKKAR 1969. (b) The 'floral buds' and the 'flowers' were fixed in FAA, stored in 70% ethanol and dehydrated in the tertiary butanol series. The section thickness varied from 5—10 μ. Staining was done with safranin-fast green combination. (c) Epidermal peels of the fresh as well as fixed material of normal and diseased plants were stained with Delafield's haematoxylin and mounted in glycerine.

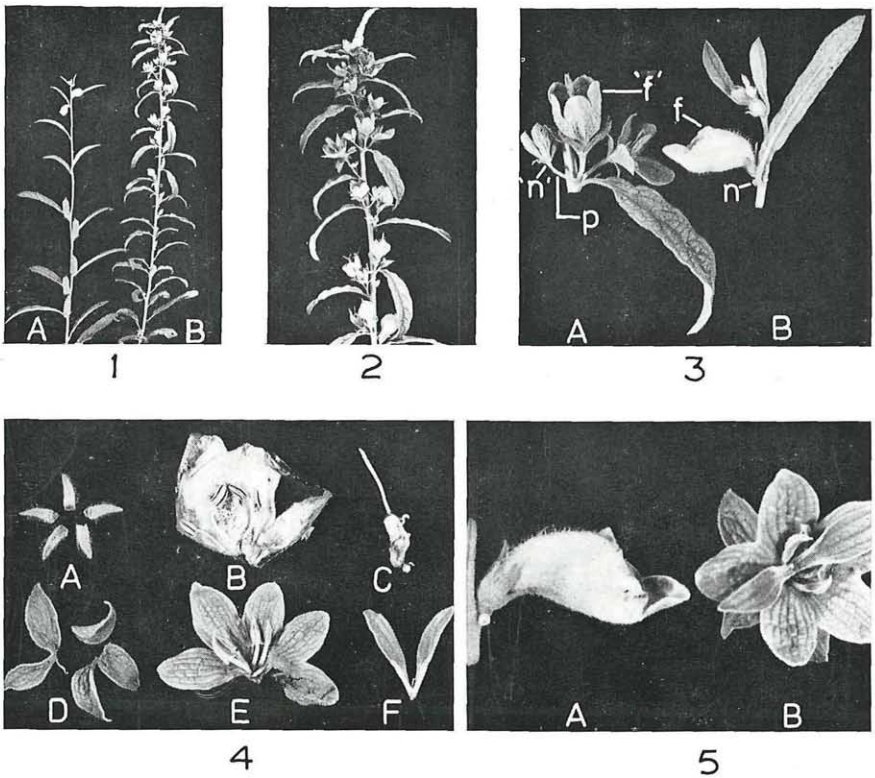
3. Observations

The various aspects covered in the study have been grouped into: 3.1. Morphology, 3.2. Epidermis, stomata and trichomes, 3.3. Venation pattern, and 3.4. Internal structure.

3.1. Morphology

The normal plants bear sessile, zygomorphic flowers (Figs. 1A, 3B, 5A). Flowers are gamosepalous and gamopetalous and bear 4, epipetalous stamens with dorsifixed anthers (Fig. 4B). The gynoecium is bicarpellary, syncarpous, with a superior ovary, a long style and bifid stigma (Fig. 4C). Each flower is associated with two yellow nectaries (Fig. 3B).

The disease was spotted first at the flowering stage of the plant when one or more floral appendages were seen to have become transformed into green leaf-like structures followed by abundant vegetative growth (Figs. 1B, 2). Such 'flowers' turned partially or completely actinomorphic (Fig. 5B) and were born on long pedicels (Fig. 3A). The calyx and corolla had a tendency to become 'polysepalous' and 'polypetalous' and became



Figs. 1—5. Morphological features of normal and diseased plants. (*f*, Normal flower; '*f*', Normal flower modified into 'flower' with vegetative appendages; *n*, Nectary; '*n*', Nectary modified into 'flower'; p, pedicel) — 1A. A healthy twig bearing flowers and fruits. — 1B. A diseased twig showing increase in node number, shortening of internodes, transformed flowers and absence of fruits. — 2. Figure 1B enlarged, note the morphological changes. — 3A. A node of the diseased twig bearing a leaf, a diseased flower, and 2 'nectaries' transformed into 'flowers'. × 1.15. — 3B. A normal node bearing a leaf, a flower, and two nectaries. × 0.67. — 4. Floral appendages from the flowers at 5th node. × 0.72. — 4A. Normal sepals. — 4B. Normal petals and stamens. — 4C. Normal gynoecium. — 4D. Diseased sepals. — 4E. Diseased petals and stamens. — 4F. Diseased gynoecium. — 5A. A normal zygomorphic flower. × 1.48. — 5B. A diseased regular 'flower'. × 1.48.

leaflike with expanded lamina (Fig. 4D, E). The stamens became basifixed with greatly expanded filaments and anthers, and were not epipetalous (Fig. 4E). The gynoecium turned into two leaflike structures, possibly each representing a carpel, without any differentiation into ovary, style and stigma (Fig. 4F). The nectaries also got transformed into 'flowers' with vegetative appendages (Fig. 3A). Abscission of flower buds, rather a common feature of normal plants, was not observed in phyllody plants.

3.2. Epidermis, stomata and trichomes

The walls of the epidermal cells of the transformed appendages were sinuous (Figs. 7, 9, 11, 12) in contrast to the straight or slightly sinuous cell walls of the epidermal cells of the normal floral appendages (Figs. 6,

Table I

A comparison of the epidermal characters in the healthy and diseased plants

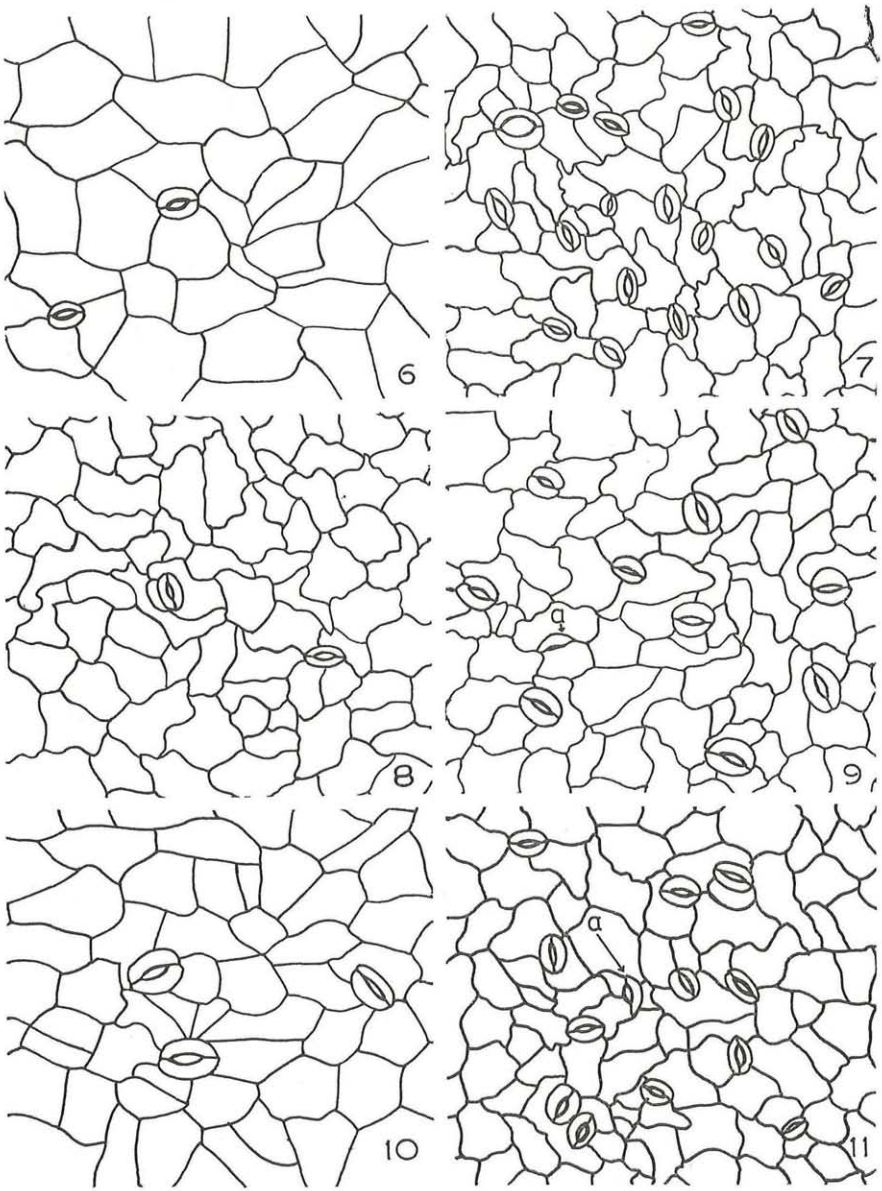
Organ	Epidermal cell no./mm²		Stomata no./mm²		Trichomes mm²	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
Sepal	173*	186.3	4.2	112.7	29	15
Petal	170	216	1.6	62.8	14	19
Stamen	89	120	8,6	44.2	14.5	19
Carpel	40	74	?	50.8	75	31.7

* The data is the average of 10 observations

8, 10). A considerable increase in the number of epidermal cells and stomata/mm² in all the four appendages of the diseased plants was noticed (Table I). The stomatal types remained unchanged, viz. a combination of anomocytic, anisocytic and rarely paracytic in both. Abnormal stomatal development was also noticed. This included stomata with a single guard cell (Figs. 9, 11), those with stunted growth (Fig. 13) and paired stomata (Fig. 12), in some of the transformed appendages. The number of trichomes per unit area increased in the diseased petal and anther but these were fewer in the diseased sepal and carpel (Table I). There was an aggregation of trichomes in regions above the veins in the diseased floral appendages.

3.3. Venation pattern

Sepal: Each normal sepal was supplied with a median strand which gave out lateral branches. The latter ramify further. Within the lamina he laterals travel parallel to median but join it at the ape x. In the trans-

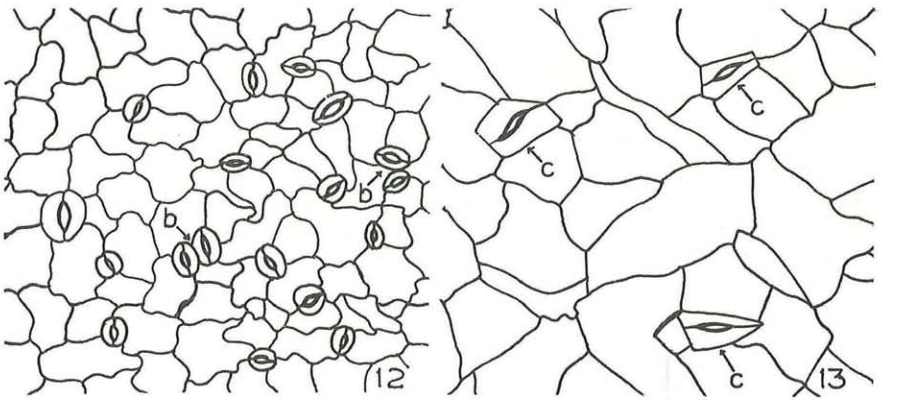


Figs. 6—11. A comparison of epidermal cells and stomata. (*a*, stomata with a single guard cell) × 200. — 6. Normal sepal. — 7. Diseased sepal. — 8. Normal petal. — 9. Diseased petal. — 10. Normal anther. — 11. Diseased anther.

formed sepal the vasculature was extensive. Here the median strand as well as the laterals became broader and gave out, unlike in the normal, numerous secondary and tertiary branches which formed numerous areoles.

Petal: Unlike in the normal petal, in the transformed petal, the primary, secondary and tertiary strands run parallel for quite a distance before giving out cross strands which formed numerous areoles.

Stamen: The normal filament was supplied by a single strand which branches at the base of the anther to supply a strand for each of the two lobes and one going through the connective. In the transformed stamens one strand coming from the filament branched at the base of anther to form primary, secondary and tertiary strands which formed some areoles.



Figs. 12—13. Epidermal cells and stomata of diseased ovary. (b, paired stomata; *c*, stomata with polygonal guard cells). — 12. × 200. — 13. × 400.

Carpel: The ovary of a healthy flower had a median strand located between the placenta and a large number of independent strands running at the margin and in the cortex of the ovary. The style had two strands. The transformed carpel which had a leaf-like structure had a primary, two secondary and four tertiary strands running parallel to each other. All the three types of strands gave out cross strands and were markedly thick and were seen to join at the apex.

3.4. Internal structure

Sepal: The mesophyll tissue of the normal sepal was represented by ground parenchyma of about 10-layers, of cells which had chloroplasts. It did not have any distinction between palisade and spongy parenchyma. The feebly developed vascular bundles were embedded in the ground parenchyma.

A transverse section of the transformed sepal simulated very much with that of a transection of a dorsiventral leaf. Just below the upper epidermis there was present a continuous layer of palisade parenchyma with cells with prominent nuclei and numerous chloroplasts. Spongy parenchyma was about 7—8 cell layer thick at the laminar region and about 25 cell layers thick at the mid rib region. The spongy parenchyma cells were thickly packed with large number of chloroplasts. The vascular strands were very well organized in having well recognizable xylem and pholem components. Each vascular strand was present in a projection which simulated the midrib or a lateral rib of a dorsiventral leaf. In the laminar region, at places, hypertrophied growth was also observed.

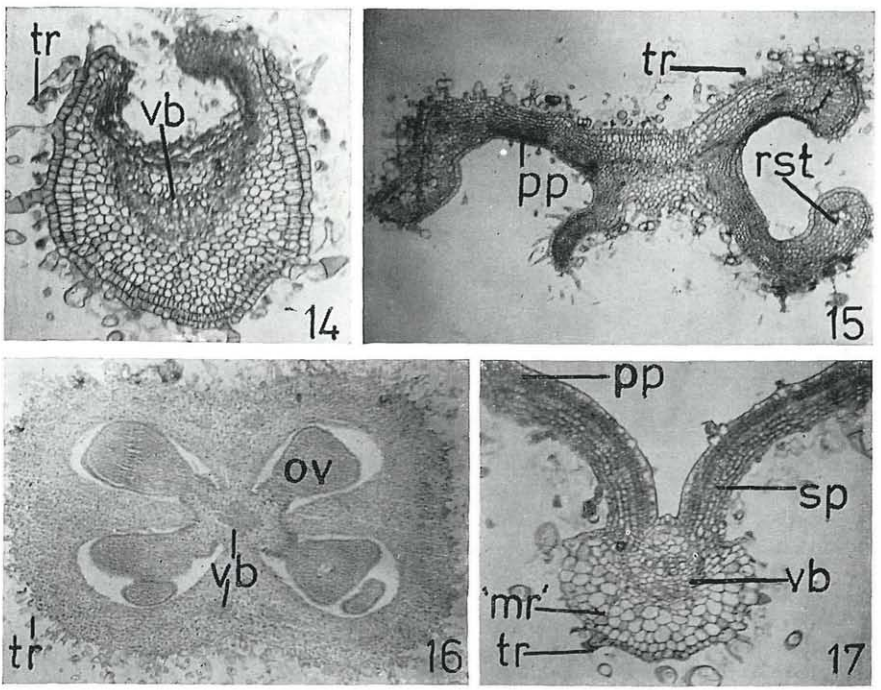
Petal: The normal petal had upper and lower epidermes with cells of variable size and different shape. The ground parenchyma which was about 10-cell layers thick had embedded in it vascular strands in large numbers. The transformed petal had internal structure very similar to a transformed sepal described above.

Stamen: The normal filament consists of a vascular bundle surrounded by parenchyma cells and epidermis. The transverse section of a transformed filament had horse-shoe shaped outline. The ground parenchyma consists of cells with fewer chloroplasts, and a large single vascular bundle embedded in it. The epidermal cells were of more or less uniform size and had numerous trichomes (Fig. 14).

The normal anther-wall has epidermis followed by endothecium, 3—4 middle layers, including a layer of glandular tapetum and normal bicelled pollen grains. The transformed anther on the other hand is partially leaf-like. All the four thecae exhibited different degrees of transformation. There is no differentiation into wall layers, or sporogenous tissue. But in the centre of the anther at places remnants of sporogenous cells could be seen. These cells were hypertrophied with many prominent nuclei and large vacuoles. A well developed vascular bundle was present in the center of 'anther' and one bundle in each of the two lobes. Only two of the four peripheral sides had palisade parenchyma (Fig. 15).

Carpel: The normal ovary had four locules with either a single or two anatropous ovules borne on axile placenta in each chamber. The main vascular strand was present in the center; a large number of them occurring in the ovary wall. The ovary wall was thickly covered with trichomes (Fig. 16).

Each of the transformed carpels had well differentiated upper and lower epidermis, a layer of palisade parenchyma and 3—4 layers of spongy parenchyma which had thick walls and fewer intercellular spaces. The mesophyll had a large number of chloroplasts per cell. At places laminar region showed hypertrophy. The well organized vascular bundles were present in the bulges simulating the midrib and the lateral ribs of a dorsi-



Figs. 14—17. Internal structure of the floral appendages. ('mr', midrib-like structure; ov, ovule; pp, palisade parenchyma; *rst*, remnants of sporogenous tissue; sp, spongy parenchyma; *tr*, trichomes; ob, vascular bundle). — 14. T. s. of diseased filament. × 130. — 15. T. s. of diseased anther. × 183. — 16. T. s. of normal ovary. × 54. — 17. Part of t. s. of diseased carpel. × 83.