Phyton (Austria)	Vol. 19	Fasc. 3–4	217–223	10. 9. 1979

Histopathology of 'Green Ear' of Bajra

By

Jyotindra Dahyabhai Patel *)

With 3 Figures (2 Plates)

Received April 29, 1976

Summary

The inflorescence of *Pennisetum typhoides* S. & H. turns green due to the attack of *Sclerospora graminicola*. The floral meristem reverts to vegetative state and forms small leaves. The morphology and anatomy of normal leaves and those from the "Green Ear" differ. The epidermis of "Green Ear" leaves shows variations from that in normal leaves. Fused leaves were found in the leaves formed by the reverted apex.

Zusammenfassung

Der Blütenstand von Bajra (*Pennisetum typhoides* S. & H.) vergrünt durch den Befall mit *Sclerospora graminicola*. Das Meristem kehrt in den vegetativen Zustand zurück und bildet kleine Blätter. Die Morphologie und Anatomie von normalen Blättern und der „Green Ears" zeigen Unterschiede. Die vom vegetativ gewordenen Vegetationspunkt gebildeten Blätter bleiben bisweilen verwachsen.

1. Introduction

It is very common to find deformed inflorescences, appearing green, with leafy appendages on its entire length or a part of it in the fields of Bajra (*Pennisetum typhoides*). This disease very commonly spreads in the crop of monsoon, and the crop of summer is less affected. *Sclerospora graminicola* is understood to cause this disease in Bajra and some other grass species (Heald 1933, Mundkur 1967). Based on the characters of the infected ear the disease is known as "Green ear disease" or "downy mildew" of Bajra. Pathology of the "green ear" is well known through the investigations of various pathologists (*see* Mundkur 1967), but the histopathological changes in the structure of inflorescences that occur due to the infection of

*) Dr. J. D. Patel, Postgraduate Department of Biosciences, Sardar Patel-University, Vallabh Vidyanagar, 388120 (Gujarat), India.

S. graminicola have not been investigated. The present investigation describes the observations on morphology and histology of "green ear" of Bajra.

2. Materials and Methods

The spikelets and leaves of the infected ears of Bajra were fixed in FAA, dehydrated through TBA series and embedded in paraffin. Longi- and transections of 8—10 microns thickness were stained using mordant safranin and fast green (Sass 1958).

3. Observations

3. 1. Morphology

During flowering season one finds the fields of Bajra (*Pennisetum typhoides*) under the attack of *Sclerospora graminicola* fungus by which the ears appear green. In normal ears spikelets and flowers develop fully leading to normal growth of the ear and grains (Fig. 1A). But due to the infection of "green ear" disease the spikelets and flowers of the entire ear (Fig. 1D—F) or a part of the ear (Fig. 1B, C) show morphological deformity and instead of forming grains thin leafy structures come out of the spike. The spread of formation of the leafy structures may be acropetal (Fig. 1B, C) or basipetal (Fig. 1E). In some cases the effect of attack of the fungus is visible only when the ear is completely exposed out of the boot-leaf. But, in a number of cases, it was very common to observe the diseased ear getting exposed off the boot leaf (Fig. 1D). In some cases, it was interesting to note that the development of the ear was completely suppressed, and only a small ball-like head was found in place of a long ear (Fig. 1F). Even in such a reduced spike the leafy outgrowths were found. However, they were very short. The leafy outgrowths vary in their width from about 0.5 to 2 mm, or sometimes more (Fig. 1E). The length of leaf blades may vary from 1—2 mm to several centimetres (3.5 cm at maximum in the presently studied lot of the material). Such leafy outgrowths, particularly those which are long, are similar in their outline morphology to the normal leaf. The sheath part of the leaf is very short. In normal case, the inflorescence bearing long axis is exposed from the point of the ligule insertion on the boot-leaf (between the two arrows Fig. 1A). However, in most of the infected cases this inflorescence axis is completely covered by the sheath of the boot-leaf and the basal part of the inflorescence and the ligule of the boot- leaf share a common point on the stem (Fig. 1B), or a very short inflorescence axis is exposed (between two arrows in Fig. 1C, E). In many cases, of the studied lot, the boot leaf of the diseased plant had longer sheath than that in the normal plant.

3. 2. Histology

3. 2. 1. Spikelets

The spikelets of the diseased ears in which the leafy outgrowths were just emerging out were dissected out for their histological examination.

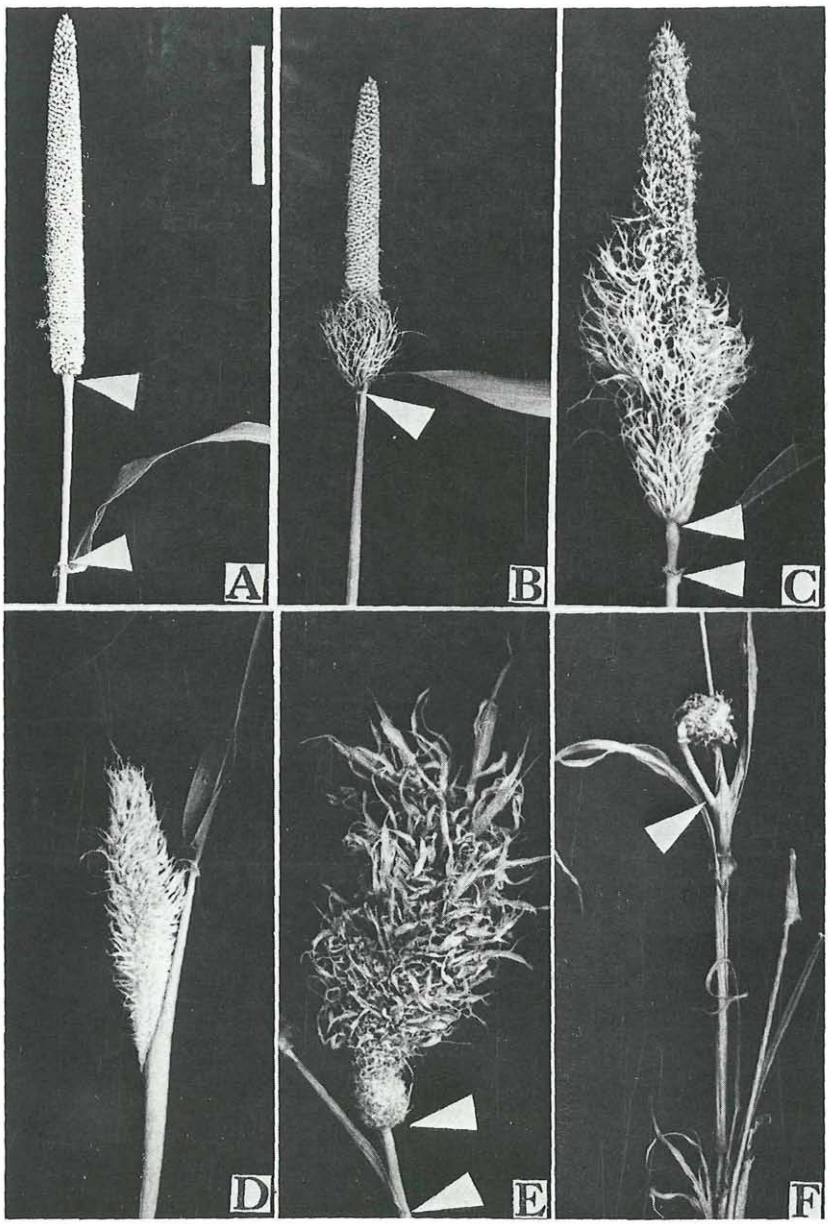

Fig. 1A—F. Morphology of ears. — A: Normal ear. — B—F: "Green Ears". (Explanation of arrows in the text). The scale represents 15 cm

Before the histological changes in the spikelets, brought about by the fungus, are described the normal structure of the spikelet is described so as to have a comparative picture of the two. There are, usually, 2- or rarely 1-spikelet fascicles inserted on the inflorescence axis with about 70—80 bristles at their base.

Each spikelet has a male and a bisexual flower each one having six chaff members, and 3 stamens in male and 3 stamens plus a monocarpellary ovary in bisexual flower (DANIEL & SHAH 1971).

The observation of a number of specimens showed that the infection of the fungus does not influence the early inflorescence ontogeny, or the inflorescence apex forms normal spikelet primordia in fascicles (evident by the formation of two-spikelet fascicles — Fig. 2A). Each fascicle, of the infected ear, has got bristles at its base (arrows in Fig. 2A, C). In normal cases there are two types of bristles, large and small, with a single vascular strand each (DANIEL 1971). However, in the present investigation of diseased spikelet, it was interesting to note that the smaller bristles have only one vascular strand whereas the larger ones have 3, 4, 5 or more vascular strands (Fig. 2C).

Each spikelet formed two floral primordia as in the normal case (Fig. 2A — F_1 and F_2; 2C). Each of the floral apex forms a few chaff members (Fig. 2A, arrow-heads), and then forms leaf primordia instead of forming further chaff members, stamens and in case of bisexual flower the carpel (Fig. 2A, B). It appears that the infection occurs, or its effect is visible, only after the early organogenesis in the flower apex. The floral apex transforms into a vegetative one. The reverted shoot apical meristem is elongated and shows steep slopes on the flanks, as in the normal vegetative apex. The normal apex has two tunica layers, a zone of initials and the corpus (DANIEL 1971). The reverted vegetative apex does not show the presence of second tunica layer (Fig. 2B). The central zone of initials can not be identified on the basis of any cytohistological characters. In some cases, the cells in the outer corpus are large (arrow-heads in Fig. 2B). The stainability is also not uniform in all the regions of the apex. Density of the celluar contents in various reverted apices also varied greatly. It may be dense (Fig. 2B) or very light.

3. 2. 2. Leaf of reverted apex

The leaf blade has very little differentiation of the mesophyll tissue (Fig. 2D). The epidermal cells were not of uniform size. In one case the back to back fusion of two leaf blades, of "green ear", on their abaxial surfaces for a short distance was observed. They show the fusion at one point of the midvein only with free laminae (Fig. 2D). The abaxial epidermis of both the leaves is in continuation at the point of the fusion (Fig. 2D, at arrow). In serial transections it was observed that the two blades are not fused

throughout their lengths. They were found to be fused in the central part of the leaf length. And, the midveins of the two leaves fuse together to give the appearance of a single mid vein. But, as the sections are traced away from the central fused part on either side the two veins gradually depart from each other.

In normal vegetative leaf there is a large midvein bundle, and in the wings there are many small vascular bundles alternating with large bundles (DANIEL 1971). In the leaves of "green ear" 7—10 small vascular strands are present without alternating with any large strands (Fig. 2D). Abaxial sclerenchyma groups in relation to the larger bundles of leaf blade wings are absent unlike that in vegetative leaf of normal plant. At the margins of the normal vegetative leaf blade fibers are reported (DANIEL 1971). However, the leaves of reverted apex have no such marginal fibers. But, some times the epidermal cells of the margin are elongated. The sclerified bundle sheaths are absent in any type of vascular bundles in the leaves of present investigation unlike in normal vegetative leaves.

3. 2. 3. Epidermis and stomata of leaf of "green ear"

In normal vegetative leaf the lower epidermis of the leaf blade has long cells with undulated walls. These cells alternate with the short cells, and stomata are arranged parallel to the long axis of the leaf (Fig. 3A). The stomata have dumb-bell shaped guard cells and a pair of lateral subsidiary cells (Fig. 3A). The epidermis of the leaf of the "green ear" has no particular linear cellular arrangements as in normal leaf (Fig. 3B). The cells are short, irregular in out line, without undulated walls (Fig. 3B). Stomata are not confined in vertical rows.

Generally, the stomata are graminaceaous with a pair of dumb-bell shaped guard cells and two lateral subsidiary cells (Fig. 3B, C). But some changes in its general structure are found. They are: (1) bean shaped guard cells instead of dumb-bell shape (Fig. 3B, at arrow, 3K); (2) only one lateral subsidiary cell (Fig. 3I, J); (3) unequal subsidiary cells probably due to degeneration of the one (Fig. 3F, K); (4) presence of two lateral subsidiaries which are not completely contiguous with guard cells, and are deformed in shape (Fig. 3E, H); (5) presence of one polar subsidiary cell in addition to two lateral ones (Fig. 3D); (6) one lateral subsidiary cell on one side and two lateral subsidiary cells on the other side of a stoma (Fig. 3G). Usually, the walls of the subsidiary cells are thinner than the walls of the other epidermal cells, but in the present study they were found to be thicker than the other epidermal cells (Fig. 3C—K).

The epidermal cells of the chaff members, in some cases are heavily cutinized (Fig. 3L). Cutinization is extended deep at the junctions of anticlinal walls (Fig. 3L). In some cases the entire epidermis of a chaff member may be found to have large unicellular trichomes with pointed or

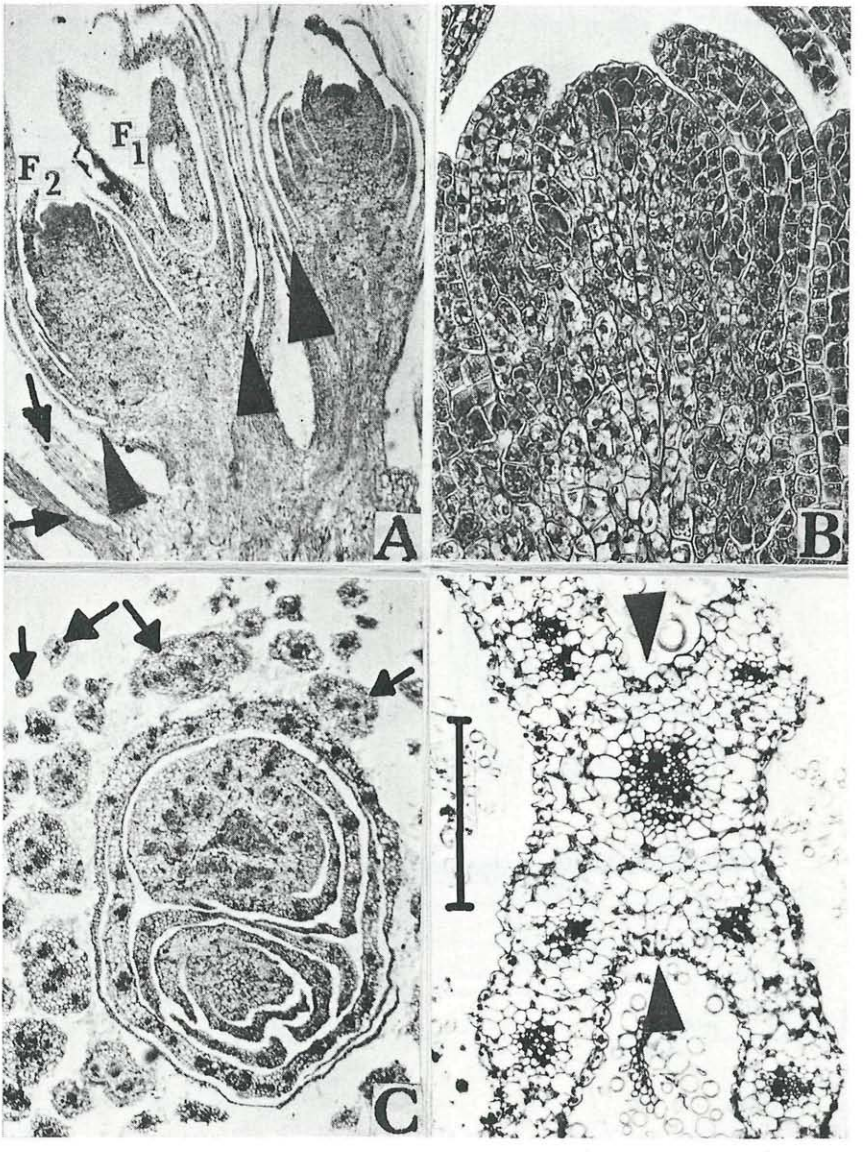

Fig. 2A—D. (F_1, F_2 = two flowers). — A: Spikelet fascicle of a diseased inflorescence. — B: Shoot apex of the reverted floral meristem showing the formation of leaf primordia. — C: Transverse section showing bristles and some chaff members of the diseased spikelet. — D: Transverse section of leaf. — Scale represents 625 μm in figs. A, C; 100 μm in figs. B, D

obtuse tips (Fig. 3M). At the intervals of 1—3 or 4 small epidermal cells, a large trichome is found (Fig. 3M). This is not found in the chaff members of a normal flower.

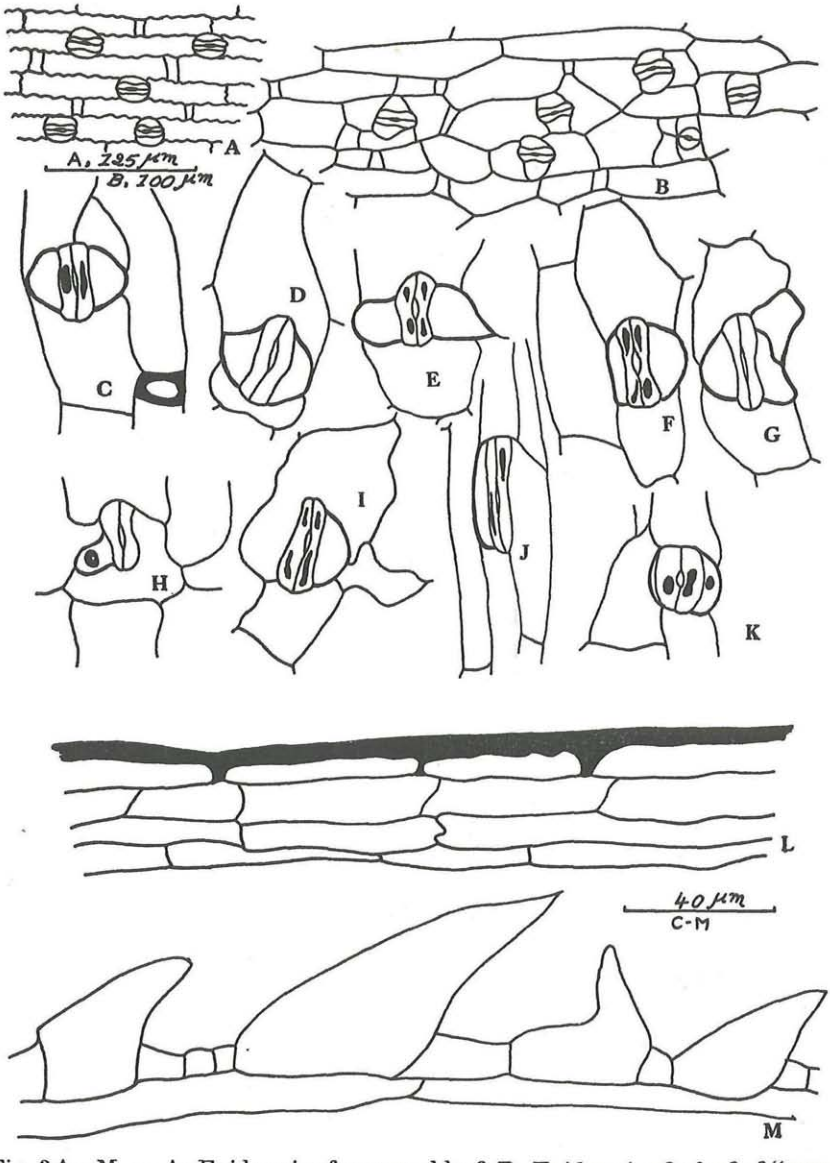

Fig. 3A—M. — A: Epidermis of a normal leaf. B: Epidermis of a leaf of "green ear". — C—K: Stomta from the epidermis of leaf of "green ear". — L, M: Epidermal structure of chaff members of "green ear"

4. Discussion

The process of reversion of the floral part or whole flower to a vegetative state has been well illustrated by the works and reviews of LANG (1965), MOHAN RAM & WADHI (1966, 1969), KRISHNAMOORTHY & NANDA (1968), PATEL & SHAH (1972). Various factors bringing the flowering plant back to the vegetative phase have been shown in the above literature. PATEL & SHAH (1972) showed the effect of virus on brinjal flowers bringing them to vegetative phase. They also observed the formation of internodes between two successive floral parts in brinjal. In the present investigation the spikelet apices revert to vegetative one after some floral parts are formed. This confirms the view point expressed earlier by BERNIER (1966) and PATEL & SHAH (1972) that the flowering stage of the plant is not irreversible one. This has been shown experimentally by MOHAN RAM & WADHI (1966, 1969). Though, the fungal infection brings about the reversion of floral apex to vegetative phase in bajra, the leaves formed by the reverted apex differ in their anatomical as well as some morphological characters. The structure of vascular bundles in the leaf blade also greatly differs from the normal leaves. The epidermal cells and stomatal structures in normal (DANIEL 1971) and the leaves of "green ear" also show a great variation.

5. Acknowledgements

I extend my thanks to the University Grants Commission for the award of a Sr. Research Fellowship during the tenure of which this work was carried out. My thanks are due to Professor J. J. SHAH for his suggestions and interest in my research progress. The morphological photographs were taken with the help of Mr. R. L. PATEL.

6. References

BERNIER G. 1966. The morphogenetic role of the apical meristem in higher plants. — Les phytochromes et l'organogénése. 38: 151—211.

DANIEL P. 1971. Developmental and anatomical studies in *Pennisetum typhoides* S. & H. — Ph. D. Thesis, Sardar Patel University, Gujarat, India.

— & SHAH J. J. 1971. Some aspects of floral histogenesis in bajra (*Pennisetum typhoides* S. & H.). — Ann. Bot. 35: 372—387.

HEALD F. D. 1933. Manual of plant diseases. — McGraw-Hill, New York, London.

KRISHNAMOORTHY H. N. & NAND K. K. 1968. Floral bud revertion in *Impatiens balsamina* under non-inductive photoperiods. — Planta 80: 43—51.

LANG A. 1965. Physiology of flower initiation. — Encyclopedia of Plant Physiology. 15/1: 1380—1536.

MOHAN RAM H. Y. & WADHI M. 1966. Reversion of floral buds of *Kalanchoe pinnata* PERS. to vegetative state in culture. — Naturwiss. 53: 558—559.

— — 1969. Morphogenic potentialities of flower buds of *Kalanchoe pinnata* PERS. grown in vitro. — Ann. Bot. 32: 825—832.

MUNDKUR B. B. 1967. Fungi and plant disease. 2nd ed. — MacMillan & Co., Calcutta, Bombay, Madras, London.

PATEL J. D. & SHAH J. J. 1972. Pathological anatomy of Brinjal affected by "Little leaf virus". — J. Indian Bot. Soc. 51: 18—22.

SASS J. E. 1958. Botanical Microtechnique. — Iowa State College Press, Ames.