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Embryogenesis in *Pennisetum pedicellatum* Trin. (Poaceae)

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ABSTRACT: Embryogenesis in *Pennisetum pedicellatum* Trin. has been studied. The first division of the zygote is transverse. Subsequent division in the proembryo is variable and can be grouped into three types according to the segmentation patterns. The shoot apex and the cotyledon are adjacent and derived from the terminal tier of the proembryo as in other monocotyledons. The structure of the mature embryo conforms to the panicoid type.

KEY WORDS: Embryogeny, *Pennisetum pedicellatum*, Poaceae.

INTRODUCTION

Pennisetum pedicellatum Trin. belongs to the subfamily Panicoideae of Poaceae and is a polymorphic species with many chromosomal races (Chatterji, 1983; Chatterji and Pillai, 1970; Chatterji and Das, 1976; Joshi *et al.*, 1959; Nath and Swaminathan, 1957). It is cultivated in different states of India as a fodder and also as a soil binder (Mukherji and Chatterji, 1955; Mukherji and Prasad 1969; Sen and Ray, 1964, Whyte, 1964).

Embryological studies have shown *Pennisetum pedicellatum* to be an apomict, with apospory as the mechanism of reproduction. (Chatterji and Pillai, 1970; Kalyane and Chatterji, 1981; Narayan, 1962). However there has been no report on the developmental aspects of the embryo in this species. The present investigation therefore was undertaken to study the embryogenesis in *Pennisetum pedicellatum* Trin.

MATERIALS AND METHODS

The material for the present study with a chromosome number of 2n=36 was collected near Fisheries college, Mangalore, Karnataka State. Inflorescences at different stages of development were fixed in FAA. The florets were dehydrated in butyl alcohol series and embedded in paraffin wax. Sections were cut at 10-12 μm thickness and were stained in phenolic haematoxylin.

RESULTS

The zygote is pyriform with dense cytoplasm at the apical end and sparse cytoplasm with a large vacuole at its basal region (Fig. 1). The first division of the zygote is transverse to produce a small terminal cell ca and a large basal cell cb (Fig. 2). The next division in the proembryo does not follow a set pattern and there appears to be three segmentation patterns.

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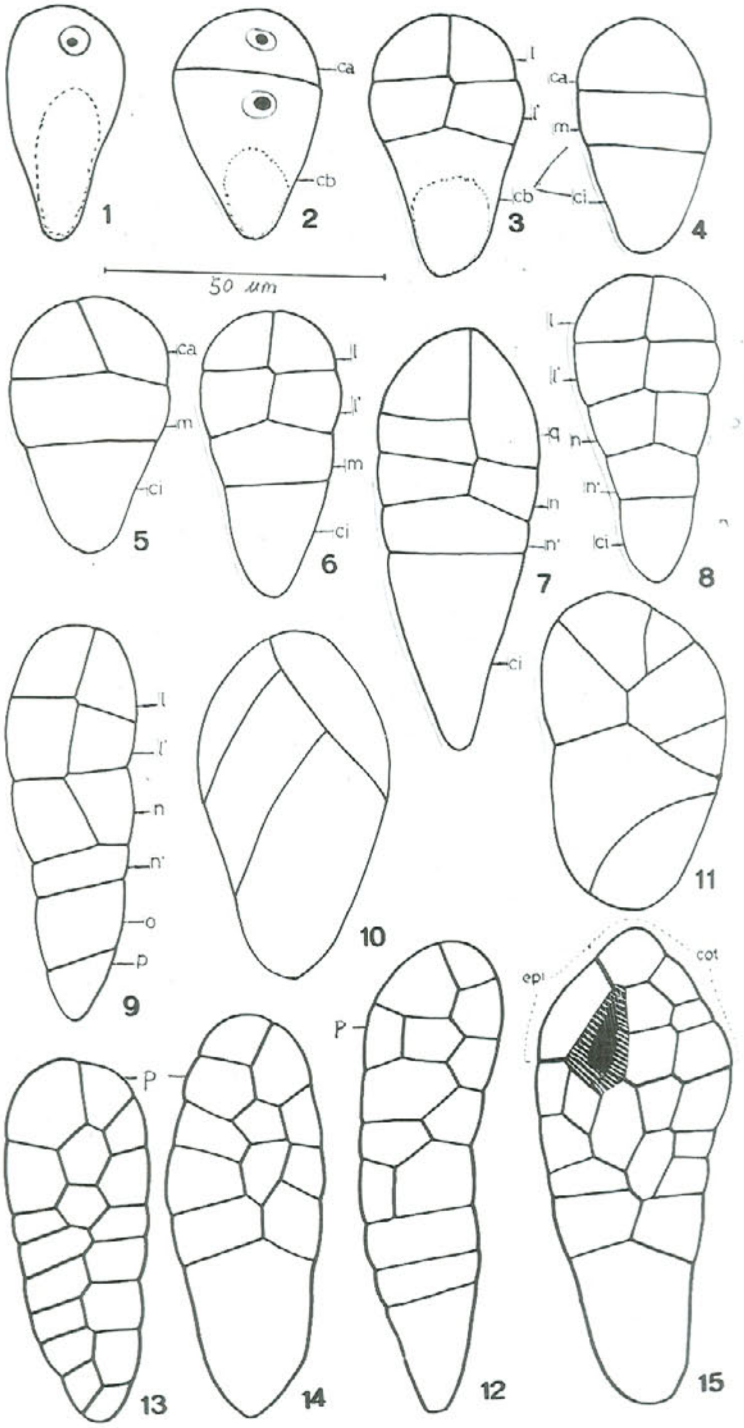

Plate 1. Embryo Development in *Pennisetum pedicellatum*. Figs. 1-2. Zygote and its first division. Fig. 3. Variation one. Figs. 4-9. Show early stages in the development of embryo-variation two. Figs. 10-11. Show young embryo dividing in oblique planes-variation three. Figs. 12-14. Show divisions in the terminal region of the proembryo to form the protoderm. Figs. 15. L. S. of young embryo showing cotyledonary and epicotyledonary cells in median longisection. The epicotyledonary cells is represented as hatched area. Note: The cotyledonary cell has already undergo division, while the epicotyledonary cell has remained quiescent. cot: cotyledonary sector; epi: epicotyledonary sector; p: protoderm.

In type one, the cell ca undergoes 2 vertical divisions at right angles to each other followed by a transverse division in all the 4 cells. The resulting 8 cells are disposed in 2 tiers to form l and l' (Fig. 3).

In type two, the cell cb divides transversely to form cells m and ci (Fig. 4). This is followed by a vertical division in cell ca. (Fig. 5). The cell ca divides by one more vertical division at right angles to the previous one and a transverse division in all the 4 cells to form l and l' (Fig. 6). Alternately the formation of octant stage may be delayed after the cell m divide transversely to form cells n and n' (Figs. 7 and 8). The cell n then undergoes an oblique division (Fig. 9).

In type three, the proembryo divides by oblique division only (Figs. 10, 11). Thus in the present investigation the early planes of division in the proembryo does not follow any definite pattern but shows 3 types of variations.

Formation of the protoderm by periclinal divisions is first seen in the terminal tier of the proembryo (Fig. 12). This trend of divisions soon extends towards the base of the young embryo (Figs. 13, 14). From this stage onwards the derivatives of the quadrant cells begin to show differences as confined to the each half hemisphere. The cells of the epicotyledonary sector show dense cytoplasm with less vacuoles while the cotyledonary sector consists of cells which exhibit poor staining capacity and more of vacuoles (Figs. 23, 24). In Figs. 15 and 16, the hatched cells represent the epicotyledonary cells with dense cytoplasm and non hatched cells represent the cotyledonary cells. In addition the rate of cell divisions in the two sectors show variation. The cotyledonary cells undergo rapid divisions while the epicotyledonary cell in comparison, undergo one or two divisions (Figs. 17, 18, 19). Thus the differential growth behaviour manifests itself early in the ontogeny of the proembryo showing clearly the cotyledonary and epicotyledonary sectors when cut in median longitudinal plane crossing through the cotyledon-epicotyl axis. Figs. 16a, 17a, 18a, 19a, 20a shows the two sectors of the proembryo in transverse plane.

The cotyledonary sector undergo rapid divisions and eventually matures into the scutellum. The epicotyledonary sector which exhibit slower rate of growth is the future shoot apex. Due to the rapid divisions in the cotyledonary sector the epicotyl occupies a lateral position. By the time the scutellum has obtained its morphological identity, the epicotyl will have undergone just one or two divisions (Figs. 20, 21, 22). Thus in the present investigation the scutellum and epicotyl are derived from the terminal tier of the proembryo and are adjacent to each other.

The tier m of the proembryo and its derivatives give rise to the hypocotyl while the derivatives of ci gives rise to the root. The cells of the tier m divide at a faster rate than ci thus the polar region of the radicle is narrow in diameter.

The scutellum increase in height by the activity of subapical initials located hypodermally (Fig. 21). The differentiation of the procambium from the subapical initials is acropetal. As the scutellum increases in height differential growth occurs on the ventral side of the embryo. This results in a depression on the dorsal side. This outgrowth above the depression give rise to the coleoptile (Figs. 21, 22, 25). The tip of the coleoptile gradually extend on either side of the shoot apex meristem and cover it completely (Fig. 22a).

The differentiation of the radicle occurs simultaneously with the development of the scutellum. The root meristem cuts off derivatives both towards the shoot pole and towards the suspensor pole. In the mature root, the corticle and the stelar region become distinct histologically within the stele where the metaxylem mother cells (MMC) become

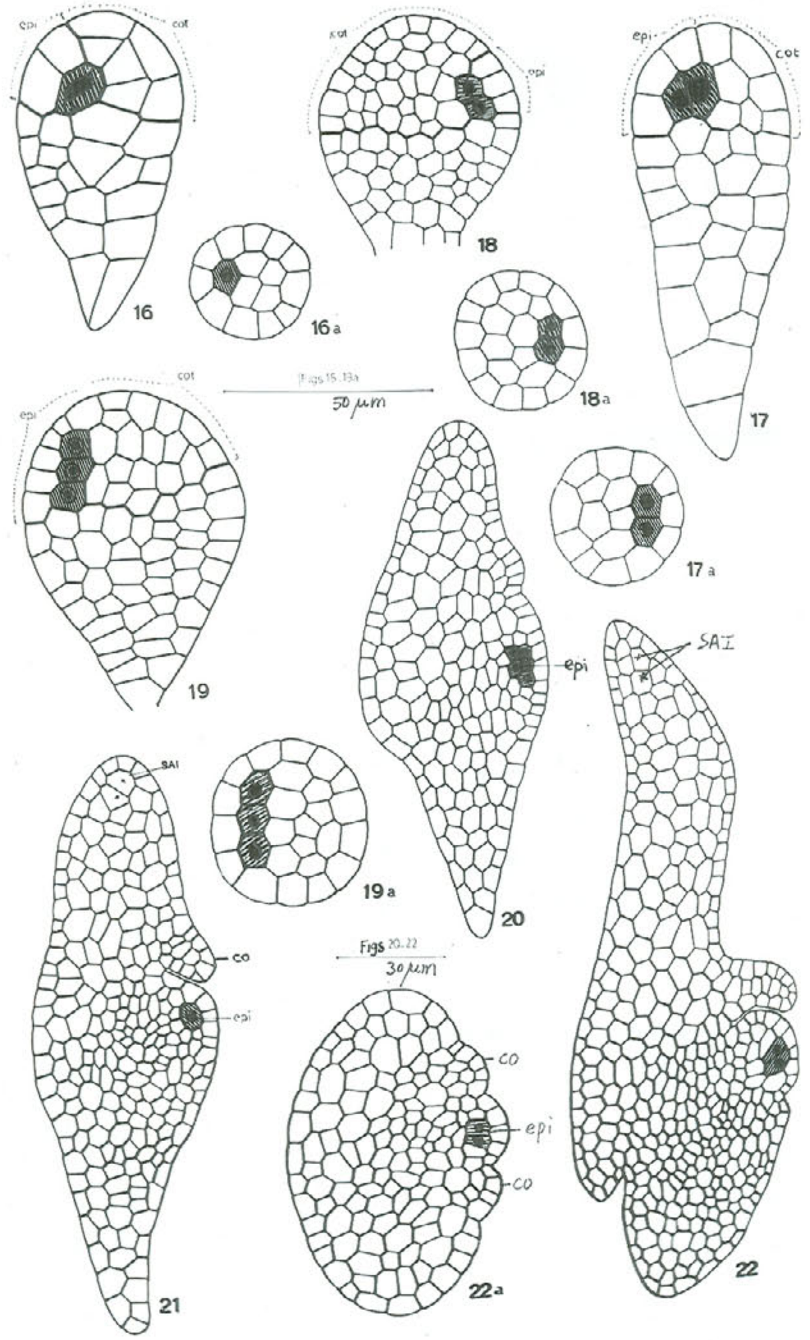

Plate 2. Embryo Development in *Pennisetum pedicellatum.* Figs. 16-19. Show longisections of globular embryo at different stages of development. Figs. 16a-19a. Show corresponding embryo in figs 16-19. in transverse section. Note: The cells in epicotyledonary sector (hatched) have undergone one or two divisions while the cells in cotyledonary sector (non hatched) have undergone several divisions. Figs. 20-22. Show longisection of older embryo showing initiation of coleoptile and formation of subapical initials in the cotyledon. The epicotyledonary cells (hatched) has remained quiescent while that of cotyledonary sector (non hatched) has undergone several division to grow past the epicotyl which has come to occupy a lateral position. Figs. 22a. Embryo in transverse section showing initiation of coleoptile. co: coleoptile; cot: cotyledonary sector; epi: epicotyledonary sector; SAI: subapical initials.

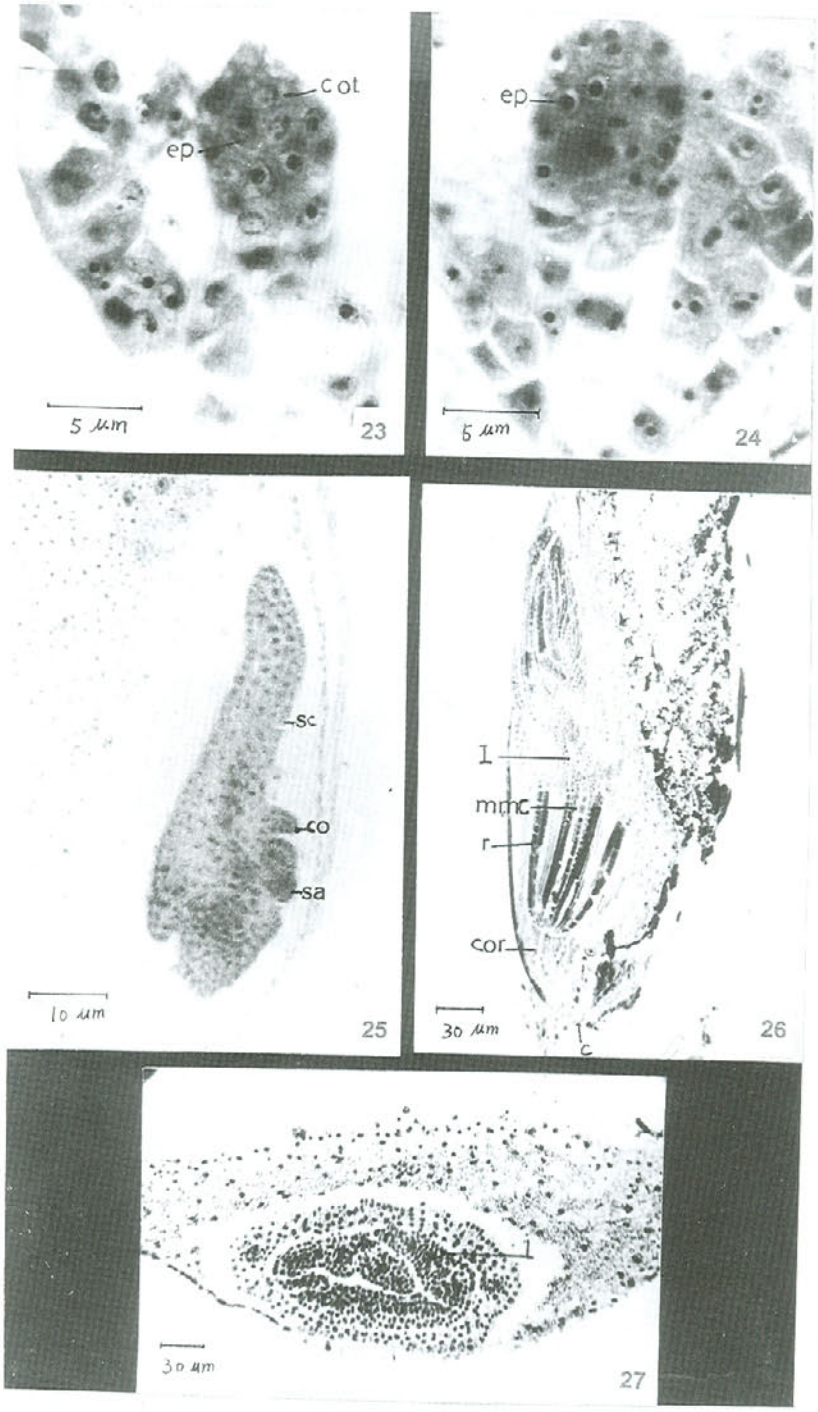

Plate 3: Photomicrographs. Fig. 23. L.S of young embryo showing epicotyledonary and cotyledonary sector. The former is represented by a single cell which has dense cytoplasm while the latter has already undergone division. Fig. 24. L. S. of globular embryo showing epicotyledonary cell. Fig. 25. L. S of mature embryo showing initiation of coleoptile. Fig. 26. L. S. of mature embryo showing an internode between scutellum and coleoptile and metaxylem mother cells in the radicle and a cleft between coleorhiza and coleoptile. Fig. 27. T. S. of mature embryo showing overlapping leaf margins. c: cleft; co: coleoptile; cor: coleorhiza; cot: cotyledonary cells; ep: epicotyledonary cells; h: hypocotyl; I: internode; L: first leaf; mmc: metaxylem mother cells; r: radicle; sa: shoot apex; sc: scutellum.

differentiated (Fig. 26). After the MMC become differentiated the hypocotyl becomes delimited clearly with regard to its upper and lower boundaries (Fig. 26).

The structure of the mature embryo conforms to the panicoid type having the formula (P-PP) i.e., in median longitudinal section the embryo is characterised by the presence of a distinct internode between the scutellar and coleoptilar bundles, a distinct cleft is present between the coleorhiza and the scutellum, and the epiblast is absent (Fig. 26). In transection the first embryonal leaf shows overlapping margins (Fig. 27). The mature embryo occupies nearly half the length of the caryopsis.

DISCUSSION

Pennisetum pedicellatum is a polymorphic species with 3 well established chromosomal races of 2n=36, 48 and 54. Other aneuploid numbers of 2n=30, 32 and 35 are also reported (Chatterji and Pillai, 1970). Narayan (1962) has reported apomixis in this species (2n=36), showing both 4-nucleate aposporous sacs and 8-nucleate sexual sacs. Chatterji (1983), has reported the occurrence of 4-N aposporous sacs in all the biotypes (A B C D & E) of this species. Our investigations in *Pennisetum pedicellatum* (2n=36) showed the presence of both 4-N and 8-N sacs indicating facultative apomixis (to be published elsewhere).

The early segmentation pattern of the proembryo in *Pennisetum pedicellatum* of the present investigation is variable and do not conform to any of the recognised embryogenic types of Batygina (1969); Johansen (1950) or Schnarf (1931). According to Randolph (1936); Merry (1941); Bennett (1944); Poddubnaya - Arnoldi (1964) Philips and Haccius (1976), Shobha and Sindhe (1986) the pattern of early segmentation in the proembryo is irregular and hence no special significance is attached to the cell lineages. The present observations of embryo development in *Pennisetum pedicellatum* support the conclusion of these authors.

The origin of shoot apex in monocotyledons has been a subject of controversy for more than a century. Haccius (1952), Baude (1956) and Swamy and Padmanabhan (1962) have clearly demonstrated that the cotyledon and the epicotyl are initiated from the terminal loci of the proembryo. Among grasses, Guignard (1961, a, b) Batygina (1968), Norstog (1969), Philips (1972) and Philips and Haccius (1976), Shobha and Sindhe, (1986) have clearly demonstrated the terminal origin of cotyledon and epicotyl as in other monocotyledons. The present investigation in *Pennisetum pedicellatum* also reports that the cotyledon and the epicotyledon arise from the terminal tier of the proembryo.

The structure of caryopsis, embryo and seedlings has been used for classifying the family Gramineae into major groups. The structure of mature embryo particularly with reference to its systematics significance has been studied by several workers (Bruns, 1892; Van Tieghem, 1897; Yakovlev, 1950; Stebbins, 1956; Reeder, 1957; Kinges, 1961). Reeder has recognised six kinds of grass embryos including the Panicoid embryo. According to him the Panicoid embryo has the formula PP-P (P minus PP) meaning that in median longisection the coleoptile and the scutellar bundles are separated by a distinct internode (P), an epiplast is absent (-), a cleft occurs at the lower portion of the scutellum and the coleorhiza (P) and the transection the margins of the first embryonal leaf overlap (P). Reeder has also considered the size of the embryo as a character of taxonomic significance. According to him the Panicoid grasses have large embryos in relation to the size of the seed compared to the Festucoid grasses. The structure and size of the mature embryo in *Pennisetum pedicellatum* conforms to the panicoid type proposed by Reeder (1957).

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花梗狼尾草（禾本科）的胚胎發育

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摘　　要

本文研究花梗狼尾草（*Pennisetum pedicellatum*）的胚胎發育，其受精卵的第一次分裂為橫向分裂，而原胚之後所進行的細胞分裂則具差異，根據其細胞分裂的型式可區分為三型。胚芽頂端與子葉相連，且如同其它的單子葉植物，均是來自於原胚的頂層細胞。由成熟胚胎的構造可確認其是黍屬型胚胎。

關鍵詞：胚胎發育學，花梗狼尾草，禾本科。

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