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ERECT CULM INTERNODAL ANATOMY AND PROPERTIES OF SUN ECOTYPE OF *IMPERATA CYLINDRICA* (L.) P. BEAUV

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Abstract

Internodal anatomy of *Imperata cylindrica* (L.) P. Beauv. was described in this paper. Culm internodes were completely encircled by leaf sheath. Peripheral vascular bundles were many in number and small in size. Central bundles were large in size and a few in number. Large bundles were of various sizes and vascular tissues well developed. Each vascular bundle had strong mass of sclerenchyma tissue arching over the phloem in the form of phloem hood. Small bundles were poorly developed in respect of vascular tissue. A small percentage of vascular bundle consisted of phloem tissue only fundamental ground tissues were parenchyma in nature.

Introduction

Imperata cylindrica (L.) P. Beauv. (Fam. Poaceae) is commonly known as Cogon Grass (Bangla: Chan). In Bangladesh it grows in fallow lands, road side, river bank and saline costal zone. It is a perennial, rhizomatous grass that grows 2 - 4 feet in height. The plant invade and overtake the community forming a dense mat of thatch and leaves that make it nearly impossible for other plants to coexist. *I. cylindrica* grows in loose to compact bunches, each 'bunch' containing several leaves arising from a central area along a rhizome. The leaves directly originate from the ground level with 1 to 2 short erect internodes. The plant has been utilized in south-east Asia as forage only when very young but mature leaves are used in making roof of village cottage. Genus *Imperata* Cyr. comprises ten species but the species *I. cylindrica* is widely distributed through out the world due to its great adaptability to various habitats, including drought and costal saline area. It has been listed as one of the seven worst weeds of the world (Holm *et at.* (1977). Flint and Paterson (1980) found two ecotypes, 'sun' and 'shade' ecotypes, based on morphological traits. Matumura and Nokajima (1988) described several biotypes in Japan. In Bangladesh shade ecotypes are shorter in height and flowers all round the year, while Sun ecotypes taller in height and flowers in autumn (October-November). Most of the works published on *Imperata* discussing its biology, ecology in respect of soil binding and preventing soil erosion, and its control over spread. As Sone is a C4 grass, Kranz anatomy and physiology have been reported in some publication (Hameed *et al.* 2009). As Sone exhibited wide range of adaptability and as no works on anatomical features in culm internodes are available, the present work was undertaken to investigate the anatomical features in respect of tissue and their distribution in two basal internodes through taking transverse sections and discussed.

Materials and Methods

Samples of *Imperata cylindrica* (L.) P. Beauv. were collected from the edge of Botanical garden, Rajshahi University during October-November, 2010 when the plants were in full bloom. Ten plants from each of three sample areas selected at random and 2 cm in length was taken from

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the base of Internode-1 and Internode-2 of a main tiller for anatomical study. The materials was fixed in formaldehyde acetic alcohol fixative (FAA) for 48 hrs and subsequently transferred to acetic alcohol solution (acetic acid 25% and ethanol 75%) for a long term storage. Free hand sections were prepared by a series of dehydration in ethanol using single-stained technique with Safranine stain. Measurements were taken with a microscope through image analysis using *Motic J1.0* software with the help of Macintosh computer. Data on anatomical traits were recorded using all 10 plants in each sample area. The traits recorded were dermal, vascular, ground and mechanical tissues.

Results and Discussion

The erect culm internode was circular in outline with solid pith. These internodes were tightly rapped with leaf sheath (Fig. 1). Two internodes down to seed head bearing internodes were studied and had the same general structure. Except in rare occurrence, the internode number was two. In general, transverse section consisted of epidermis and ground tissue. The ground tissue was not differentiated into cortex and pith, since there was a scattered arrangement of vascular bundles (Figs 1-2). Even endodermoid layer and pericycle were not differentiated. Hypodermis consists of parenchyma cells, small in sizes, and vascular bundles noted right from hypodermis.

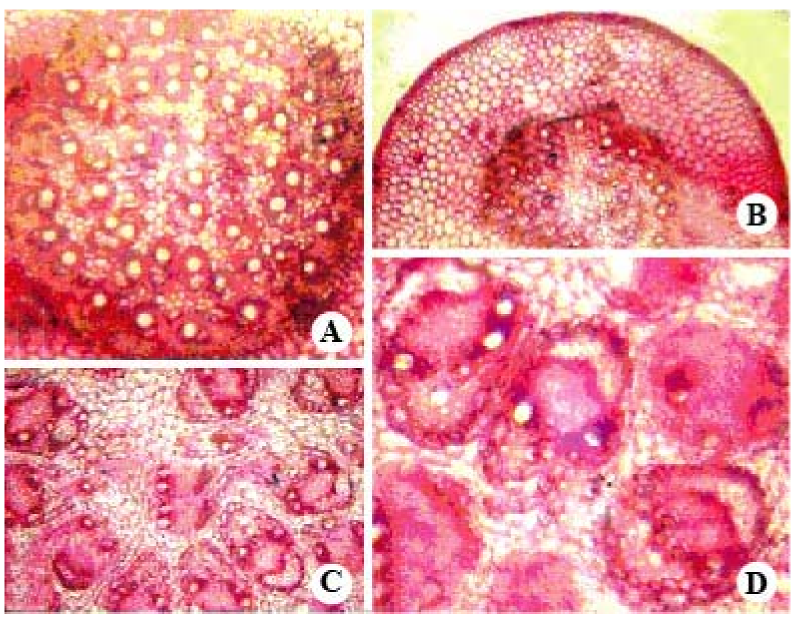

Fig. 1. Transverse section showing arrangement of different tissue and tissue system in erect culm internodes. A. Distribution of vascular bundles in internode-1. B. Complete rapping with leaf sheath of internode-1. C. Central region of T.S. of internode-1. D. some central vascular bundles of internode-2.

The fundamental ground tissue was parenchymatous and the cells were larger in the central regions. The fundamental tissue distribution and arrangements conform with the monocotyledon maize type (Fahn 1995, Esau 1965). In Napier and Kas, vascular bundles are scattered down in the hypodermis (Hossain 2010).

Vascular tissue consisted of numerous oval to radially elongated vascular bundles scattered throughout the ground tissue (Figs 1, 2 and 3). Peripheral vascular bundles were small in size but many in numbers. Grosser and Liese (1971) noted considerable variation in the appearance of the vascular bundles within one culm, both across of the culm wall, longitudinally and along the culm in bamboo. Mohmod *et al*. (1992) reported four types of vascular bundles in different bamboo species. Hypodermal vascular bundles are smaller in size reported in many monocotyledonous species (Grosser and Liese 1971, Hossain 2011, Joarder and Sima 2011, Joarder 1980). The central vascular bundles were large in sizes, comparatively thinly distributed and few in numbers. In all vascular bundles the xylem and phloem were in the same line; cambium absent; phloem was only external to xylem; protoxylem when present faces the centre (Fig. 1-3). Hence the vascular bundles were described as conjoint, collateral, endarch and closed. Each vascular bundle was surrounded by a single bundle sheath of parenchymatous in nature. Xylem comprised single metaxylem vessels but in rare occasion two, pitted facing the periphery and few protoxylem elements facing the centre of the stem in a linear row. Above the metaxylem vessel phloem was seen. A strong cap like hood over the phloem, made up of thick walled sclerenchyma tissue, was seen.

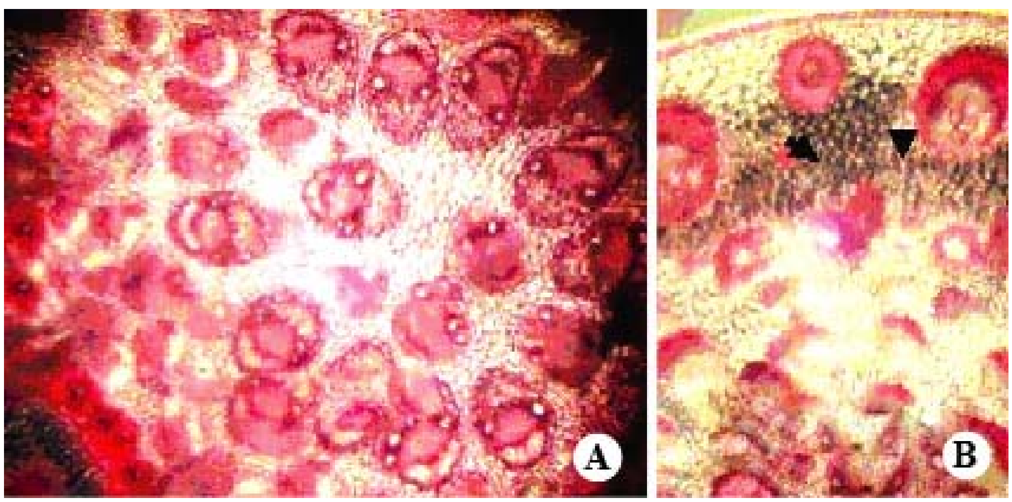

Fig. 2. Arrangement of vascular bundles in internode-2. A. Distribution. B. Vascular bundle not differentiated into full bundle (arrow head).

Leaf sheath encircling internodes were composed of parenchyma cells and had few small vascular bundles embedded in the ground tissue. Vascular bundles were not properly developed (Fig. 1). In sugarcane leaf sheath vascular bundles are well developed (Colbert and Evert 1982)

Vascular bundles: Internodal vascular bundles were of different sizes and shapes. Hypodermal bundles were smaller in sizes and more or less oval or round in shape (Fig. 3). Vascular bundles always had single metaxylem vessel with protoxylem element. Inner bundles were anticlinally elongated and had phloem hood over the phloem made up with thick walled cells. Phloem hood was within the bundle sheath. Phloem well develops. At least in 1.7% vascular bundles no metaxylem or protoxylem vessels were observed (Fig. 3). The size of vascular bundles ranged from 1197 - 5251 mμ^2 of which 21% as phloem hood, 42% as phloem and 37% as xylem. A wide range of vascular bundle area have been reported in Cogon grass ecotypes (Hameed *et al.* 2009).

Peripheral vascular bundles were completely encircled by very thick walled bundle sheath of several cells thick (Figs 1-2). These bundles had parenchymatous bundle sheath (single layer) and inner to this few layers of thick walled cells with small lumen in them. Vascular tissues, undifferentiated, were enclosed by the inner sheath. Number of inner sheath cells ranged from 2 - 7. The size of such bundles was 884.7 ± 7.62 $m\mu^2$ of which 72% consists of inner thick walled sheath. This type of bundles was more in internode-2 compared to internode-1. It is an anatomical adaptation capable of tolerating drought and harsh environment as reported (Motumura and Nakajima 1988).

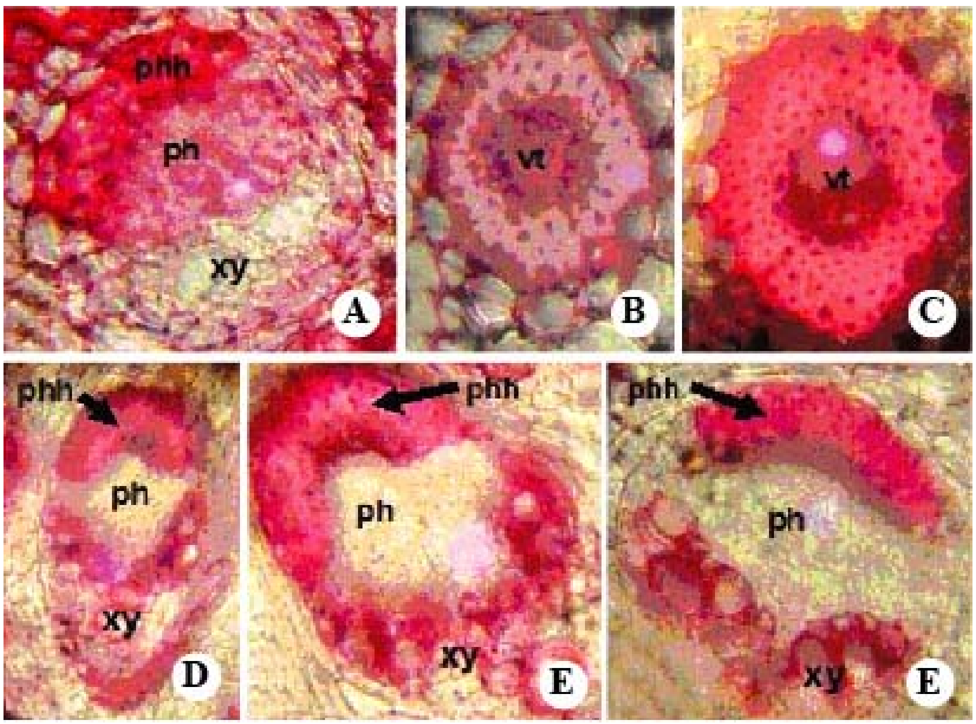

Fig. 3. Vascular bundle types as seen in T.S. A & C. Small vascular bundles in internode-1. B. Small vascular bundle in internode-2. D. & E. Central vascular bundles in Internode-1 and internode-2, respectively. F. Central vascular bundle with scattered xylem elements. phh = phloem hood, ph = phloem, xy = xylem, vt = vascular tissue.

As many as 14% of vascular bundles did not develop into full vascular bundle (Fig. 3), These bundles have phloem cap and some phloem tissue. A few bundles (1.7%) consisted of phloem tissue surrounded by fibrous cells only (Fig. 3). It is an adaptation for efficient phloem transport to underground rhizome for reserve.

A large number of central vascular bundles were radially elongated (Fig. 2). Vascular elements well developed. As we counted, this type constitutes 29.6% of the large bundles. Well developed tracheary elements including vessels, trachea etc. were visible. In few bundles xylary lysigenous cavity were clearly visible. Phloem well developed and made up with sieve tube, companion cells and phloem parenchyma. A strong bundle sheath arching over phloem in the form of hood was prominent. Phloem is surrounded by strong sclerenchyma sheath in some bamboo species (Liese 1980, 1987) Periclinal and anticlinal length of the vascular bundles was 39.4 ± 6.67 mμ and 124.6 ± 23.19 mμ, respectively. The anticlinal and periclinal length ratio of the vascular bundles was 3.16 : 1. Decrease in tangential size of the vascular bundles is an increment of strength properties of culm internodes (Mohmod *et al.* 1992). Vascular bundle area ranged from 3184 - 5249 mμ^2 with a mean of 4236 ± 721.14 mμ^2. Phloem area per vascular bundles was 1244.6 ± 311.46 mμ^2; that for xylem was 1562.1 ± 314.22, and the phloem hood consisted of 1430.3 ± 221.16 mμ^2. Xylem and phloem tissue was in a ratio of 1.26 : 1. Phloem and phloem hood area ratio was 0.87 : 1. Phloem tissue was 79.67% over the xylem tissue. Percentage of phloem and xylem per vascular bundles were 29.38 and 36.97, respectively. The percentage of phloem hood tissue per vascular bundle was 32.5.

A number of vascular bundles in the centre of the fundamental ground tissue were larger than described in above paragraph. It measured 6312.14 ± 417.46 mμ^2. These vascular bundles constitute 14.62% of the central bundles. These bundles were greater periclinal length than those described (Figs 2 and 3E). Periclinal and anticlinal length ratio was 0.32 : 1 and 0.41 : 1 in internode-1 and internode-2, respectively. These bundles have well developed tracheary elements, phloem with a large fibrous hood over the entire phloem tissues. Vascular bundles were surrounded by thin walled bundle sheath. Lysigenous cavity was visible in rare occasion. Xylary elements consisted of vessels, and trachea with pitted wall. Phloem well developed and consisted of phloem parenchyma, sieve tube and companion cells. Crushed protophloem was visible in many bundles.

Vascular bundle distribution is a strength property of the internode (Sulthani 1989). Increased number might be accompanied by increment in the greater number of sclerenchyma and conducting cells, and density, thus increases the strength properties of the internodes (Mohmod *et al*. 1992)

Each measurement is attached with a large standard error which is an indication of existence of differences between plants within a sample. High variation in measurements of anatomical traits has been reported in different ecotypes of Cogon grass (Hameed *et al*. 2009). Polygenic controlled traits in rice and wheat exhibited high variation grown under different environmental conditions (Joarder 1980, Sima 2010). Hossain (2010) noted strong environmental effects on the expression of anatomical traits and each estimate is attached with high standard error in wild sugarcane.

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