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ANATOMICAL RESPONSES OF JUTE (*CORCHORUS CAPSULARIS* L. CV. D-154) TO WATERLOGGING

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Abstract

The effect of waterlogging (about 2 cm depth for 14 days) on anatomical structure in jute (*Corchorus capsularis* L. cv. D-154) plants grown in sand culture experiment was studied. Waterlogging resulted in the development of adventitious root, aerenchyma in the cortex of the stem. It also caused a decrease in vascular area as well as size of the vessels having smaller cavity in the root, stem and leaves. Pith area was found to increase in stem under waterlogging condition. Reduced number and closed stomata were found under waterlogging condition.

Introduction

Jute is a fiber crop belongs to the genus *Corchorus* of the Tiliaceae family with two cultivated species namely, *Corchorus capsularis* L. and *Corchorus olitorius* L. In the trade, *Corchorus capsularis* is known as "White Jute" while *Corchorus olitorius* as "Tossa Jute". *Corchorus capsularis* is also popularly known as ‘Deshi Jute’. Jute, the ‘Golden Fiber’ of Bangladesh, is contributing about 4% GDP to the national economy and earns about 5% of the foreign exchange as well(1). As this fiber crop is often grown in dry-wet transition period, water logging and excessive moisture often cause damage to this plant.

Among abiotic stress, extremes of water availability, waterlogging is a major problem limiting production and productivity of the most crops(2). The primary stress factor induced by waterlogging is reduction in soil oxygen availability. Thus survival of plants under waterlogging condition depends on the ability of transport oxygen from aerial to hypogeal organs(3). When waterlogging condition occur regularly, some plant species are alike to responded to anatomical modifications that allow sustained growth and adventitious root development(2). Formation of adventitious roots is one of the most adaptive responses of crops under waterlogging conditions(4). Additionally, aerenchyma is developed in the cortex of new and existing roots of some plant species which is thought to increase waterlogging tolerance(5). The objective of this study was to investigate the effect of waterlogging on anatomical structure of jute plants (*Corchorus capsularis* L.).

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Materials and Methods

Seeds of jute (*Corchorus capsularis* L cv. D-154) were obtained from Bangladesh Jute Research Institute, Dhaka. Plants were grown in sand culture[6] in half-strength Hoagland solution[7]. Seeds were germinated on purified quartz sand contained in earthen pot lined with polythene. Seven-day-old seedlings were subjected to waterlogging (about 2 cm depth). After application of waterlogging for 14 days the root, stem and leaf of waterlogged plants and control were collected and preserved in FAA solution for anatomical study. Freehand cross-sections of the root, stem and leaf were done followed with safranin staining for microscopic observation. Photomicrographs of the stained specimens were taken using a camera attached with the microscope. Stomata in leaves of control and waterlogged plants were also observed.

Results and Discussion

Effects of waterlogging on anatomy of the root: Adventitious root formation was observed under waterlogging condition. The development of adventitious roots are characteristics of waterlogging tolerant plants and it may help the plants towards better accessibility of above ground oxygen[8]. In waterlogged plants, the cortical parenchyma cell sizes were comparatively smaller with smaller intercellular spaces compared to control (Fig. 1 A, B). Abundance of xylem rays were found in control roots than that of treated ones. Drastic change in phloem tissue was noticed in waterlogging roots (Fig. 1A, B). Under waterlogging treatment, vascular area was found to decrease and occupy less area with less number of xylem vessels having smaller cavity (Fig. 1D). Reduced number of metaxylem and protoxyllem vessels as well as the reduced diameter of the vessels (Fig. 1F) were observed in waterlogging condition which could lead to a reduction in root axial conductance for water movement[9]. Ballesteros *et al.*[10] reported that the lumen area of vessels showed a significant decrease by almost 39% under flooding condition in *Alnus glutinosa*. Pith area as well as pith cells became reduced by waterlogging (Fig. 1D).

Effects of waterlogging on anatomy of the stem: The epidermal cells became smaller, irregularly organized and outer wall of epidermis became thickened under waterlogging condition (Fig. 2B). The cortical cells under waterlogging was found to be discontinuous compared to that of control (Fig. 2A, B). Arenchyma was developed in the cortex under waterlogging (Fig. 2B, D). Aerenchyma development is one of the adaptive mechanisms of plants ability to cope with anaerobiosis. Aerenchyma allows plants to transport the atmospheric oxygen to the submerged organs to maintain aerobic respiration. Yin *et al.*[11] reported that aerenchyma was formed in the stem of *Dendranthema nankingense* under waterlogging. Waterlogging resulted in decrease of periderm layer. Lenticels formation was observed under waterlogged condition. Lenticell formation due to waterlogging is reported by Bertolde *et al.*[12] in 35 *Theobroma cacao* genotypes. Large pith area with irregular cell size was observed in waterlogged plants as compared to control (Fig. 2E, F).

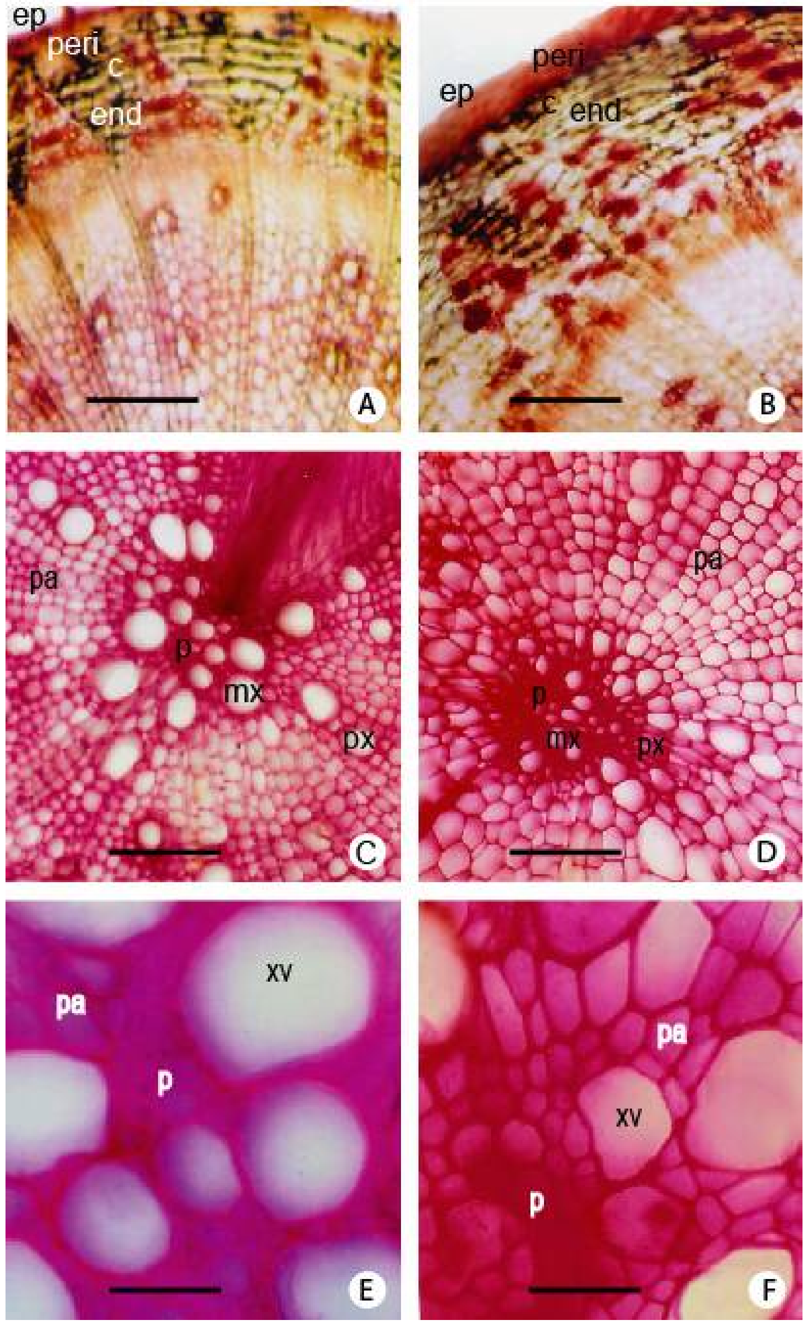

Fig. 1A-F: Transverse section of the root of *Corchorus capsularis* L. (21-day-old plant) grown in sand culture treated as control (A,C,E) and as waterlogging (B,D,F). c = Cortex, en = Endodermis, p = Pith, xv = Xylem vessel, px = Protoxylem, mx = Meta xylem, peri = Pericycle, pa = Parenchyma. Bar = 100 µm.

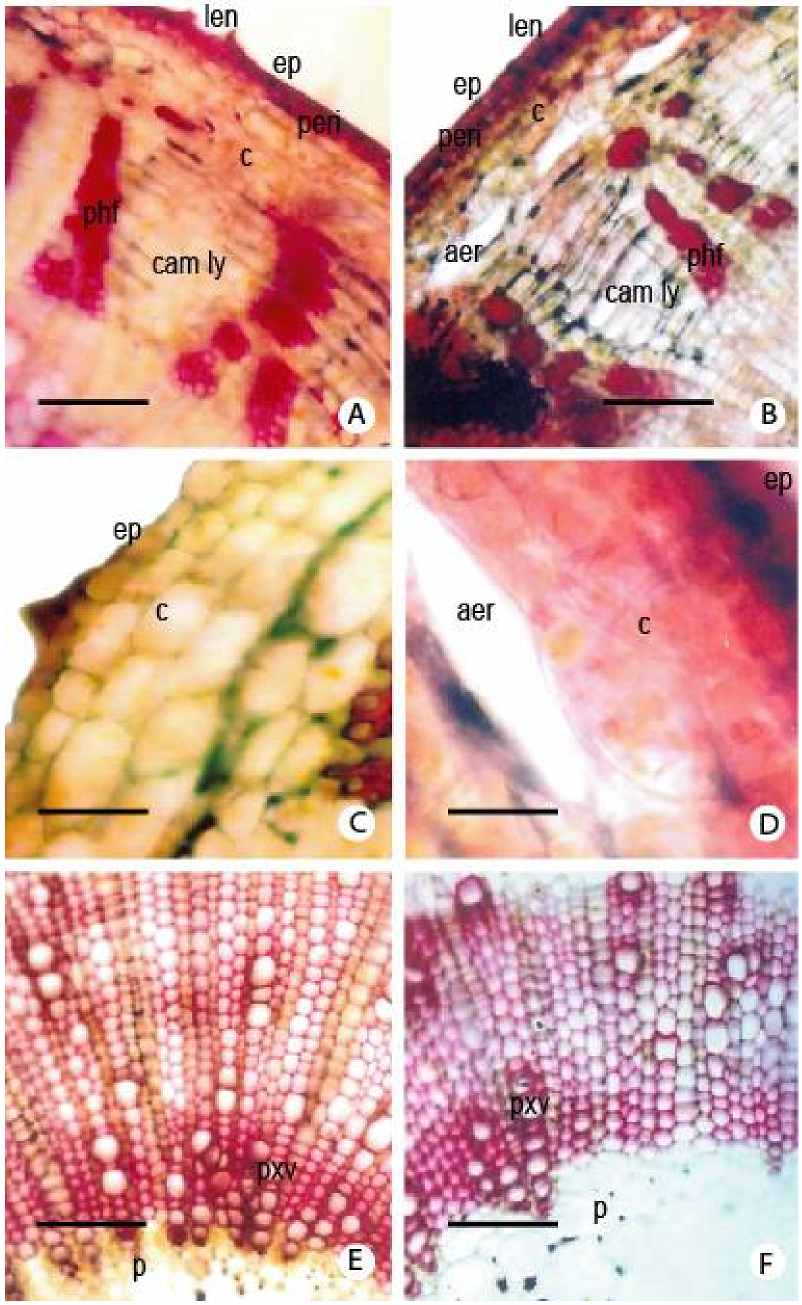

Fig. 2A-F: Transverse section of the stem of *Corchorus capsularis* L. (21-day-old plant) grown in sand culture treated as control (A,C,E) and as waterlogging (B,D,F). ep = Epidermis, c = Cortex, phf = Phloem fibre, pxv = Primary xylem vessel, len = Lenticel, peri = Periderm, cam ly = Cambium layer, aer = Aerenchyma, p = Pith. Bar = 100 µm.

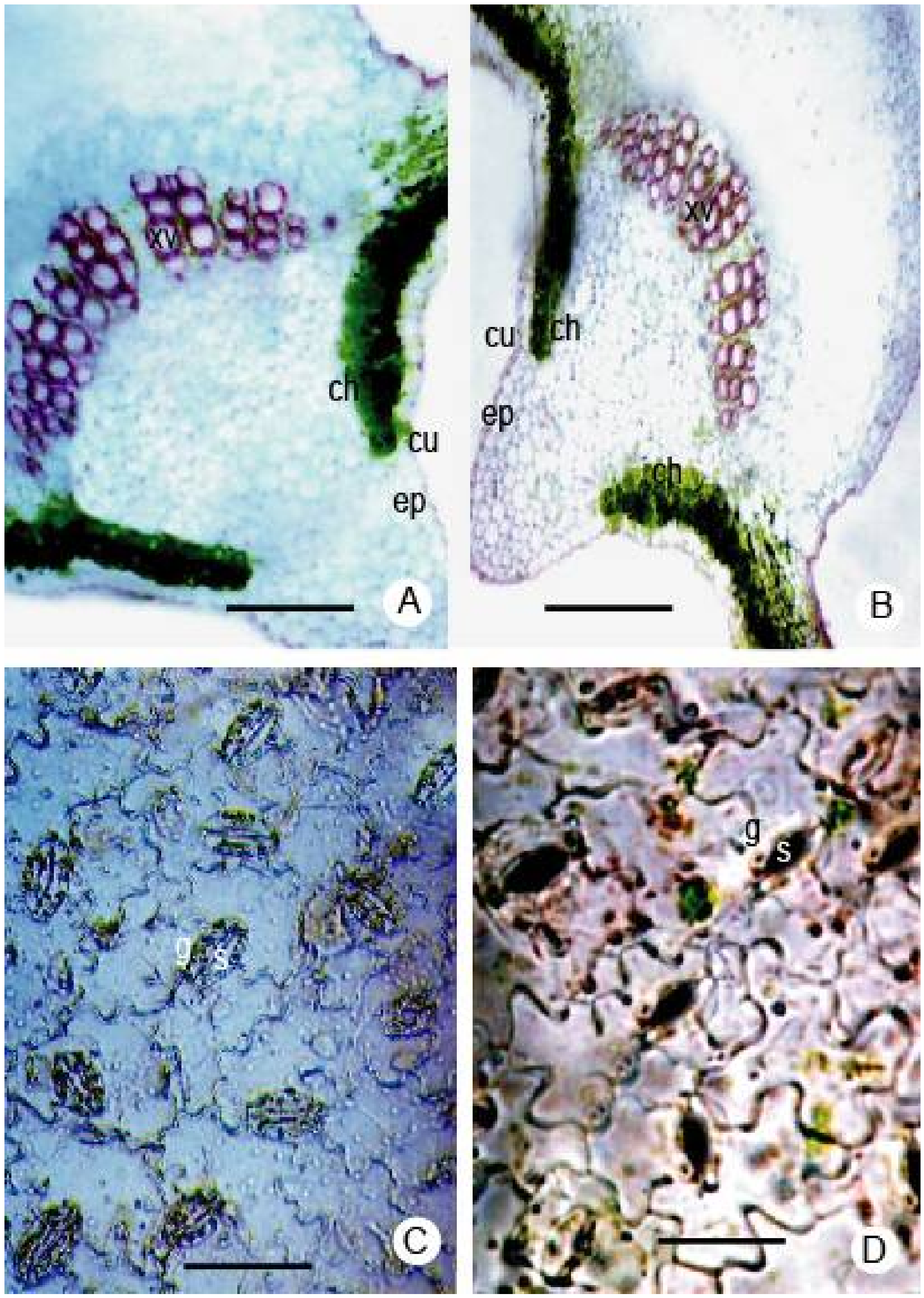

Fig. 3A-D: Transverse section of the leaf of *Corchorus capsularis* L. (21-day-old plant) showing vascular area in control (A) and waterlogging condition. (B). Peeling of *Corchorus capcularis* L. leaf showing stomata(s) and guard cell (g) in control. (C) and waterloged. (D) Plant. ep = Epidermis, xv = Xylem vessel, cu = Cuticle, ch = Chlorenchyma tissue. Bar = 100 µm.

Xiao *et al.*(13) observed increased pith diameter under waterlogging in *Avicennia marina.* Phloem sclerenchyma (phloem fiber) cells were found outside the cambium layer and these were more in numbers in control compared to waterlogged plants (Fig. 2A, B). In waterlogged plants, smaller size of the xylem vessels and less xylem elements were present as compared to that of control. Less phloem sclerenchyma cells were found under waterlogged condition (Fig. 2B).

Effects of waterlogging on anatomy of the leaf: Leaf thickness was decreased under waterlogging condition and this is supported by the findings of Xiao *et al.*(13) in *Avicennia marina*. Epidermal cell became smaller, irregular and disorganized in waterlogged jute plants compared to control (Fig. 3A, B). Thin cuticle, reduced layer as well as smaller size of chlorophyllous cells in mesophyll and less amount of chlorophyll were observed in waterlogging plants compared to control (Fig. 3A, B). Similar result was observed by Wang *et al*.(14) in *Bruiguiera gymnorrhiza* waterlogged seedlings. Under waterlogging condition leaf showed smaller vascular area with less xylem elements, reduction in size and number of metaxylem vessels to that of control (Fig. 3A, B). Similarly, Xiao *et al*.(13) found declined number of vessels in waterlogged *Avicennia marina.* Reduced number of stomata was observed in leaves of waterlogged plants than that of control plants (Fig. 3C, D). Stomata were closed and smaller in size under waterlogging condition (Fig. 3D).

Plants respond to variations in the content of soil water and oxygen through morphological, anatomical and physiological adjustments that help them cope with such variations. Species from flooded habitats show increased ability to respond plastically to flooding with an increase in the proportion of aerenchyma. Flooded plants respond such stress. Jute plants subjected to waterlogging condition in this experiment make adjustments to waterlogging by the development of adventitious roots, formation of aerenchyma and stomatal closure as well as other modifications for better adaptation.

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