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Anatomical Characteristics of Rice Plants Influencing Resistance and Susceptibility to Yellow Stem Borer

M Shahjahan

Department of Entomology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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Plant anatomical characters presumably influencing resistance and susceptibility to yellow stem borer (YSB) infestation were studied. Rice varieties having broader and thicker sclerenchymatous hypodermis, compact parenchyma cells of ground tissue, small air spaces in the ground tissue, more vascular bundles with narrower spaces between vascular bundles, ridged stem surface containing vascular bundles and narrower pith are considered to be characters for resistance. Whereas thinner sclerenchymatous hypodermis, loose parenchyma cells of ground tissue, larger spaces between vascular bundles, wider pith and larger air cavities, might be responsible for the susceptibility to (YSB). In the present study TKM6, BR1 and Nizersail were found to be resistant to (YSB), while TN1, IR8, BR3, BR4 and BR14 were susceptible varieties.

Key words**:** Rice varieties, (YSB) yellow stem borer, Anatomical characters, Resistance.

Introduction

Stem borers are major pests of rice in Bangladesh. The predominant species is *Scirpophaga incertulas* (Walker). The other pyralid, *Chilo polychrysa* (Meyrick), *Scirpophaga innotata* (Walker) and the noctuid, *Sesamia inferens* (Walker) occur in varying proportions, depending upon the locality and the extent of cultivation of rice and other graminaceous crops. The yellow rice stem borers could be controlled considerably by modern organic insecticides, but the effectiveness of this measure depends on the proper timing of the insecticide application to coincide with the vulnerable stages of the pests. The insecticide control is temporary, and the use of insecticide is limited because they destroy natural enemies of the pest, as well as because of their toxicity to mammals and fish. Moreover, in areas where overlapping insect generations occur, repeated treatments are required to keep their numbers below levels that will cause economic damage. The problem is further complicated when frequent rains remove insecticide residues (Pathak 1967).

Thus, it is important to study control measures, which will result in cumulative reduction in the insect population. The use of relatively resistant varieties as a means of control in endemic areas, in addition to the other control methods, has great economic potential (Israel 1967). This method has been found to be particularly effective against insect pests, like yellow rice stem borer, which have high host-plant specificity and because of feeding habits and difficulty to reach with conventional methods of control. The host-plant resistant method operates at all levels of the pest population and is compatible with other methods of control.

Stem borer larvae have to eat their way into the stem, it would be expected that stems with thick culm tissues would offer resistance to larval boring (Pathak *et al* 1971). Experiments showed that varieties with a narrow stem lumen were less susceptible to borers (Seko and Kato 1950 a and b; Van and Guan 1959; Israel *et al* 1961). Stems with thick layers of lignified tissues were less infested, and distance between vascular bundles of the stem directly correlated with susceptibility. Varieties with vascular bundles arranged closer than the width of the larval head offered resistance to larval boring. Also, varieties with thick layers of sclerenchymatous tissue were generally less infested than varieties, which had thin layers. Van and Guan (1959) believed that thickness of sclerenchymatous tissue to be the major basis of resistance.

The present research work was undertaken to study the plant anatomical characters presumably influencing resistance and susceptibility to YSB infestation.

Materials and Methods

Resistant and susceptible varieties of rice plants were grown in the BAU Farm in aus and aman seasons of 1996. Twenty one rice varieties in aus (TKM6, TN1, IR8, IR29, BR1, BR2, BR3, BR6, BR7, BR8, BR9, BR12, BR14, BR15, BR16, BR20, BR21, Dular, Gomvir, Hashikalmi and Purbachi) and eleven rice varieties (TKM6, TN1, BR4, BR10, BR11, BR22, BR23, Kalizira, Nizersail, Purbachi and Tulsimala) in aman season were grown for this study. Specimens of rice stem from basal parts were collected after 100 days of transplantation and fixed in FAA (Formalin-aceto-alcohol) fixative. The stem parts were washed in running water for 5-6 h and dehy-

drated in a series of ascending grades of alcohol (i.e. 30, 50, 70, 80 and 90% upto absolute alcohol for 5-10 min each. The dehydrated specimens were kept in cedar wood oil for a period of ½ h to overnight. The cedar wood oil was removed form the tissue by placing it in xylene for ½ to 1 h. It was then transferred to melted paraffin, a commercial embedding compound of M.P 56 to 58°C and placed in an incubator at 60°C. Several changes of the paraffin (e.g. ½ xylene + ½ paraffin for 1 and ½ h liquid paraffin for 2 h pure paraffin at 60°C for overnight) were made over a period of approximately 8 h to overnight and the tissue was embedded in it and blocks were prepared.

A rotary microtome adjusted to cut section 5-10 microns thick and was used. The ribbon of section was placed in hot water bath at a temperature of 50°C and after the film was uniformly stretched the ribbon of sections was transferred to moistened slide that had been coated with a very thin film of Mayer's egg albumen fixative. Slides were usually left on the hot plate (approximately 45°C) overnight for drying. Heidenhains iron hematoxylin and safranin following the methods of Grideley (1960) and Metcalfe (1960), stained the sections in slides. The stained sections were covered by a cover slip, mounted on Canada balsam and these were examined under microscope to study the variation of anatomical cha-racteristics of resistant and susceptible varieties.

Results and Discussion

Anatomy of stem of rice varieties in transverse section is shown in Fig 1-8. The hypedermis of rice variety TKM6, is found to be composed of three layers of heavily lignified sclerenchymatous cells (Fig 1a and 1b). Vascular bundles are fairly and closely arranged in two distinct circles, the outer one is either within or attached to the hypodermis and the inner one is distributed in the middle of the ground tissue. There are five vascular bundles in the outer circle and six in the inner circle (Fig 1a).

The hypdermis of BR1 consists of three layers of sclerenchymatous cells. The parenchyma cells of ground tissue are much compact. Vascular bundles are arranged in two rows, the outer row is in the middle of the ground tissue (Fig 2a and 2b). A half ring of smaller sized compact parenchymatous tissue connects the vascular bundles of outer circle. A small air cavity is seen within the half ring. The arrangement of one vascular bundle of outer and inner circle is in the same radial line whereas there is an another vascular bundle in the inner circle appearing just below the half ring. There are two vascular bundles in the outer row and four in the inner row (Fig 2a).

The hypodermis of Nizersail consists of three layers of sclerenchymatous cell. There are two rows of vascular bundles; the outer row is located within the hypodermis and the inner is in the ground tissue (Fig 3a and 3b). The surface of the stem is not smooth, but with some ridges each containing one vascular bundle. There are four vascular bundles in the outer row and five in the inner row (Fig 3a).

The hypodermis of TN1 rice variety consists of three layer of sclerenchyma (Fig 4a and 4b). The parenchyma ground tissues are loosely arranged. There are two rows vascular bundles; the outer row embedded in the hypodermis forms a slight ridges on the epidermis and the inner row is distributed in the middle of the ground tissue. Five and four vascular bundles are observed in the outer and inner rows, respectively (Fig 4a).

The hypodermis of IR8 variety consists of two to three layers of sclerenchyma. Hair like projections is observed in the cuticle. Vascular bundles are arranged in two distinct circles, the outer circle is in the hypodermis forming slight ridges in the epidermis and the inner circle is in the middle of the ground

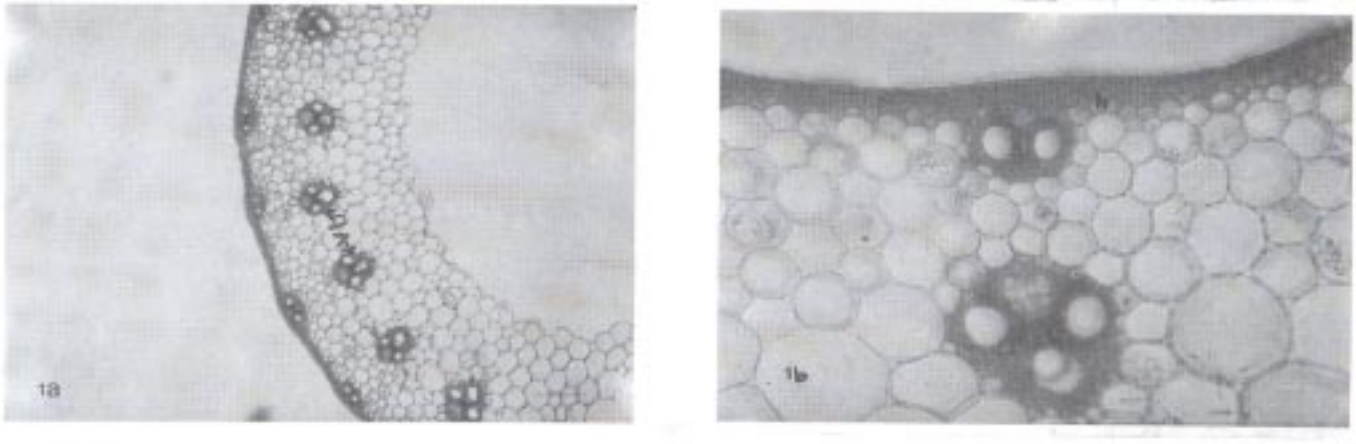


Fig 1a&b. Transverse section of the stem of TKM6 showing fairly closely arranged vascular bundles (1a) and heavily lignified hypodermis (1b) (1a, X85; 1b, X340). (h, hypodermis; vb, vascular bundle).

tissue with prominent protoxylem lacuan (Fig 5a and 5b). Three vascular bundles in the outer circle and four in the inner circle are seen (Fig 5a). Intercellular spaces of ground tissues are moderate.

Transverse sections of stem of BR3 rice are shown in Fig 6a and 6b. Three to four layers of sclerenchymatous cells are seen in the hypodermis. Epidermis forms slight ridges in which vascular bundles of outer circle are located. The vascular bundles of inner circle are not properly arranged in a row but centered in the middle of the outer circle with a prominent protoxylem lacuna. There are four vascular bundles in the outer circle and four to five in the inner circle (Fig 6a). The parenchyma cells of the ground tissue appear to be loosely arranged. Intercellular spaces are moderate.

In the transverse sections of stem of BR4 rice variety three layers of sclerenchyma are observed in the hypodermis. A row of conspicuous air cavities of unequal sizes and variable outlines, formed by the fusion of parenchymatous tissue, is

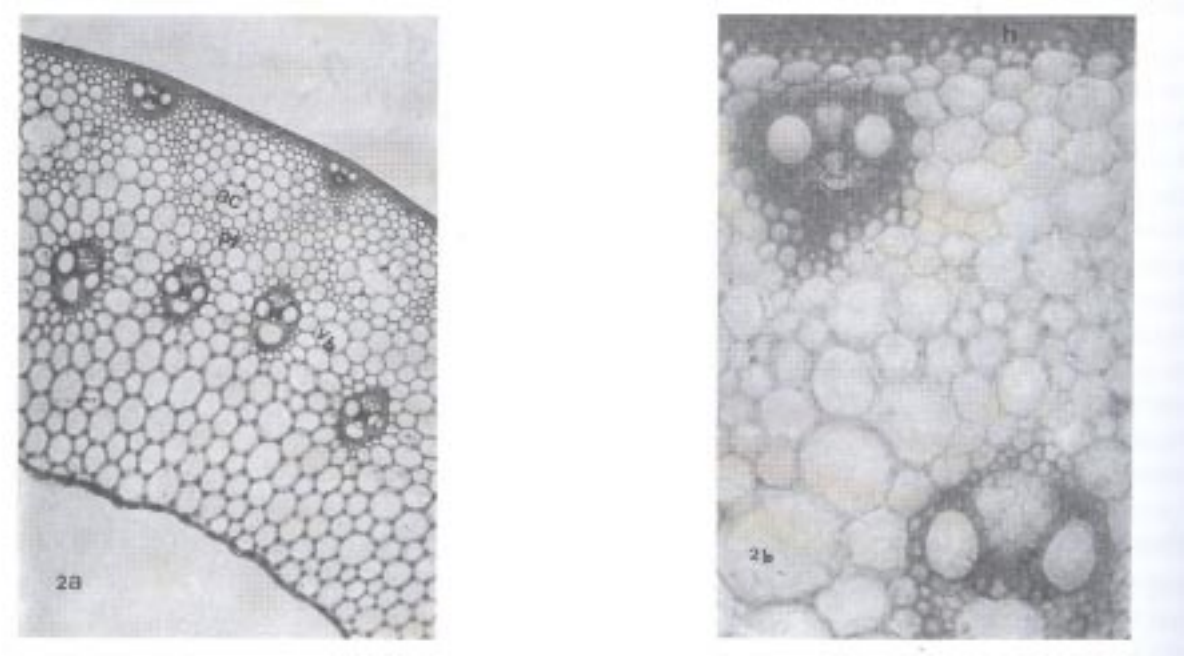


Fig 2a&b. Transverse section of the stem of BR1 showing highly lignified hypodermis (2b) and radially arranged double circled vascular bundles, the outer one connected by a half ringed compact parenchyma beneath which lie an additional vascualr bundle (X85). (ac, air cavity; h, hypodermis; pt, parenchymatous tissue; vb, vascular bundle).

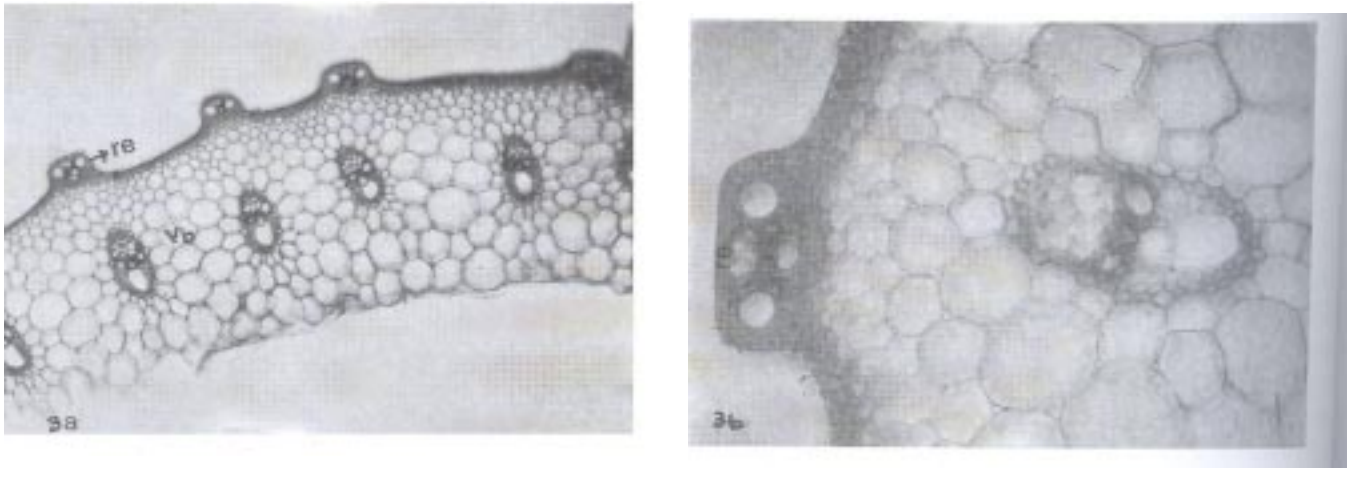
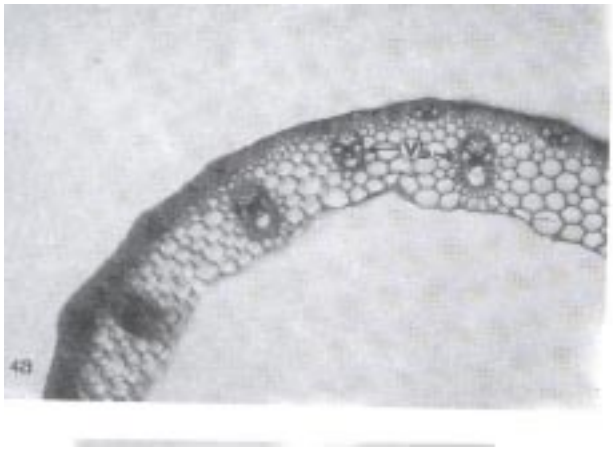


Fig 3a&b. Transverse section of the stem of Nizersail showing ridged epidermis bearing outer rows of vascular bundle, the inner rows of vascular bundle being grounded in the ground tissue (3a, X85; 3b, X340). (re, ridged epidermis; vb, vascular bundle).



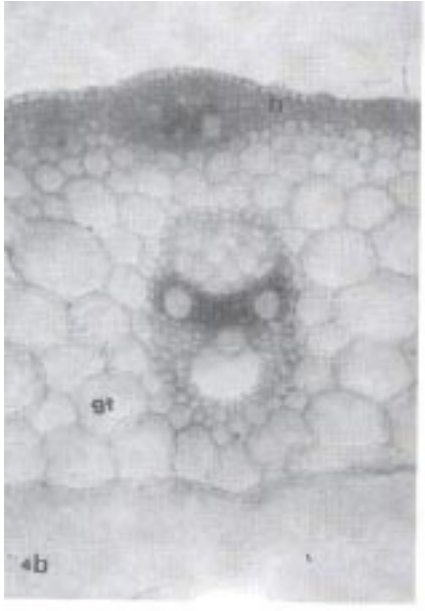
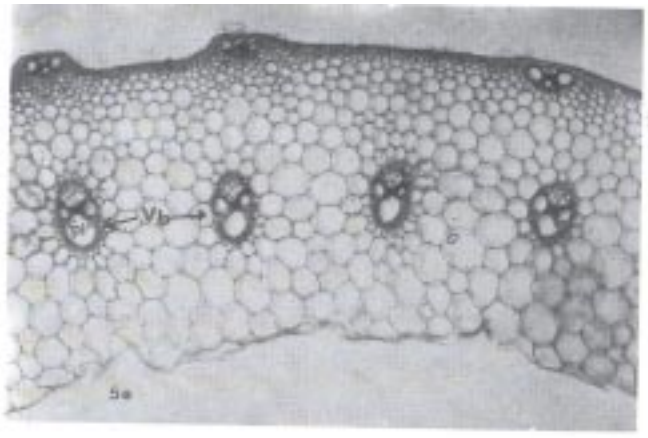


Fig 4a&b. Transverse section of the stem of TN1 showing loosely arranged ground tissues, the outer rows of vascular bundle embedded in the hypodermis and the inner rows distributed in the middle of the ground tissue (4a, 85; 4b, X340). (gt, ground tissue; h, hypodermis; vb, vascular bundle).



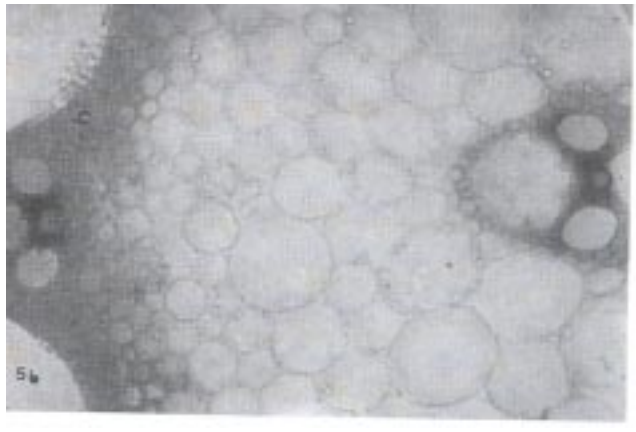


Fig 5a&b. Transverse section of the stem of IR8 showing hypodermis bearing outer rows of vascular bundle. The vascular bundle of inner rows shows prominent protoxylem lacuna (5a, X85; 5b, X340). (h, hypodermis; pl, protoxylem lacuna; vb, vascular bundle).

present in between the outer and inner circles of vascular bundles. A half ring of compact parenchyma surrounds each air cavity and this half ring connects the vascular bundles of outer circle. Vascular bundles are fairly and widely spaced and arranged in two distinct circles, the outer circle being closed to the hypodermis and the inner circle is in the ground tissue between the row of air cavities and the hollow centre of the culm (Fig 7). Only two vascular bundles in the outer circle and three in the inner circle are found (Fig 7).

In the transverse sections of stem of BR14 rice variety, three to four layers of sclerenchymatous cells are found in the hypodermis. A row of air cavities is observed in the ground tissue just in between the outer and inner circles of vascular bundles. The vascular bundles of outer circle are closed to the hypodermis, whereas the inner row is situated in between the air cavities and the hollow culm (Fig 8a and 8b). A half ring of fused parenchyma surrounds each air cavity. There are three vascular bundles in the outer circle and three in the inner circle (Fig 8a). The parenchyma cells of ground tissue are rather less compact.

The rate of infestation of YSB to different rice varieties indicates that TKM6, BR1 and Nizersail are resistant and TN1, IR8, BR3, BR4 and BR14 are susceptible to the insect pest (Shahjahan 1995). The results of the present study are in agreement with earliers (Akinsola 1973; Alam *et al* 1985; Chaudhary *et al* 1984; Heinrichs *et al* 1982) who reported that TKM6 and BR1 were resistant and TN1, IR8 and BR3 were susceptible.

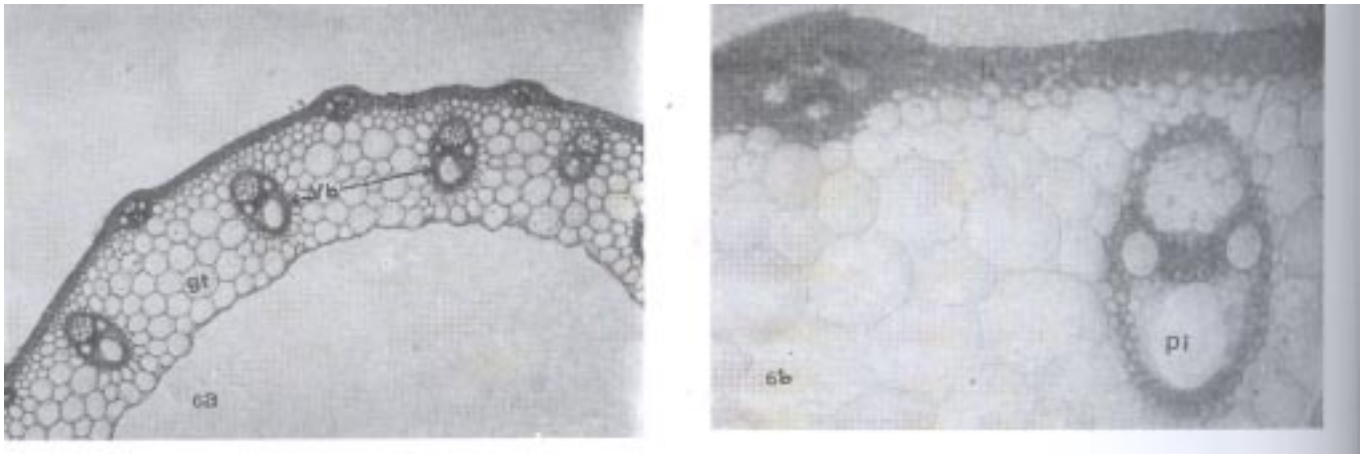


Fig 6a&b. Transverse section of the stem of BR3 showing outer circle of vascular bundles embedded in the hypodermis, the inner circle centered in the ground tissue in between the two outer bundles with a prominent protoxylem lacuna (6a, X85; 6b, X340). (h, hypodermis; gt, ground tissue; pl, protoxylem lacuan; vb, vascular bundle).

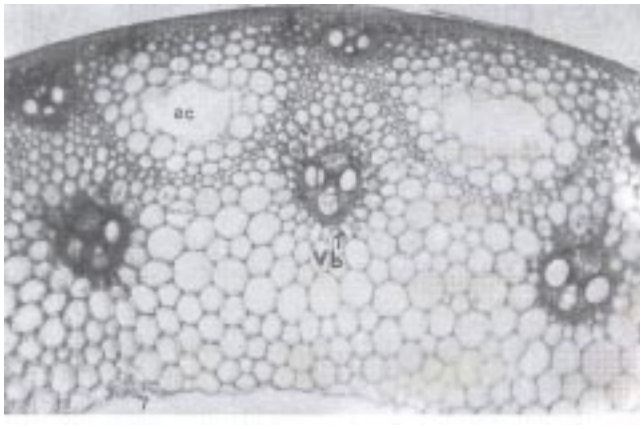


Fig 7. Transverse section of the stem of BR4 showing conspi cuous air cavities in between outer and inner circles of vascular bundle (7, X85). (ac, air cavity; pt, parenchymatous tissue; vb, vascualr bundle).

Rice varieties having comparatively broad and thick sclerenchymatous hypodermis and small air spaces in the ground tissue are considered to be resistant to YSB (Van and Guan 1959; Israel *et al* 1961; Pathak 1967). Seko and Kato (1950 b,c) reported that varieties having narrower spaces between vascular bundles also exhibits resistance to YSB. Rice varieties with ridged stem surface having vascular bundles were generally reported to be less infested by YSB than those with smooth surface (IRRI 1965). In the present study it is revealed that in BR1 rice variety the hypodermis consists of compact cells and has more vascular bundles with narrower spaces in inner circle. In TKM6, the spaces between the vascular bundles are much narrower. The additional vascular bundle in the inner circle may be one of the factors of YSB resistance. There are no air spaces in the ground tissue of TKM6 and Nizersail. Thicker hypodermis and ridges containing the vascular

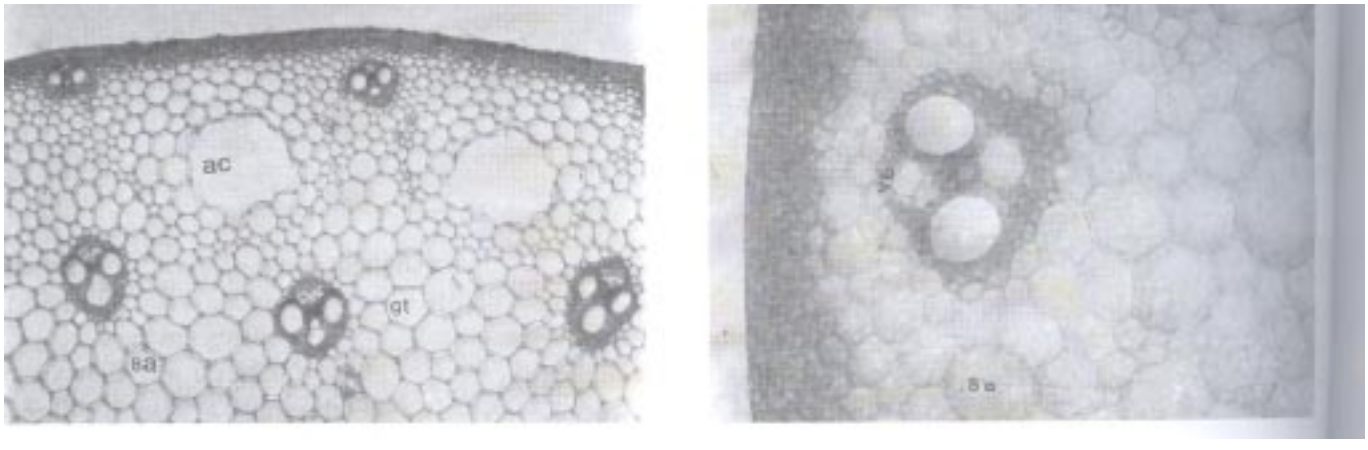


Fig 8a&b. Transverse section of the stem of BR14 showing conspicuous air cavities in the ground tissue in between outer and inner circles of vascular bundles (8a, X340). (ac, air cavity; gt, ground tissue; vb, vascular bundle).

bundles in the outer surface of epidermis might also contribute to resistance to YSB in Nizersail.

Thinner hypodermis, loose parenchyma cells of ground tissue, larger spaces between vascular bundles and wider pith might be responsible for the susceptibility of TN1, IR8, BR3, BR4 and BR14 to the YSB (Seko and Keto 1950 a and b; Israel *et al* 1961; IRRI 1964 and 1965; Israel 1967; Pathak *et al* 1971). In addition, larger air spaces of BR4 and BR14 make them more susceptible to the insect pest (Israel 1967).

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