

Title	Morphological and Anatomical Characteristics of <i>Vigna radiata</i> (L.) Wilczek. in Mandalay Region
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# Morphological and Anatomical Characteristics of *Vigna radiata* (L.) Wilczek. in Mandalay Region

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## Abstract

Morphological and anatomical characters of leaves, stems and roots of *Vigna radiata* (L.) Wilczek. belonging to family Fabaceae (Subfamily-Papilionoideae) were studied. The specimens were collected from Myingyan Township, Mandalay Region. In morphological characters, the plants were observed annual erect herb with brown hirsute. Leaves were pinnately trifoliolate compound and sparsely pilose. The flowers were bisexual, zygomorphic, pentamerous, hypogynous and papilionaceous. Pods were dehiscent, sparsely pale brown hirsute and seeds greenish or yellowish green, glabrous. In anatomical characters, paracytic type of stomata was observed on both surfaces of laminae. The opposite system of two vascular bundles was observed in the midrib. The vascular bundles of stem were showed continuous circular ring. The vascular bundles of petioles, lamina, midribs and stems were collateral type. The vascular bundles of roots were found tetrarch to polyarch.

**Key words:** *Vigna radiata* (L.) Wilczek., Morphology, Anatomy

## Introduction

The Leguminosae are one of the most economically important families. They provide food, fodder, dyes, gums, resins, oils and ornament (Lawrence 1964 and Zhengyi & Raven 2013).

*Vigna radiata* (L.) Wilczek. is belonging to Papilionoideae ranks high among the pulse crops in India. The seeds are highly nutritious and good source of protein. Sprouted seeds are eaten and sometimes seedlings are candied (Pandey 2000).

*Vigna radiata* (L.) Wilczek. (mung bean) is native to Bangladesh, India, and Pakistan. Mung beans are mainly cultivated in India, China, Thailand, Philippines, Vietnam, Indonesia, Myanmar, Australia, Iran, Eastern Africa and Bangladesh. Mung beans are commonly used in Chinese, as well as in Myanmar, Thailand, Japan, Korea, Philippines,

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Pakistan, India, and Southeast Asia. They are generally eaten either whole or as bean sprouts (Anonymous 2013).

In Myanmar, mung bean is grown in Kachin, Kayin, Kayar, Sagaing, Bago, Magwe, Mandalay, Mon, Shan (North), Yangon and Irrawady. In Myanmar, about 90% of total production of mung bean is exported to India, China, Indonesia, Malaysia, UAE, etc. Export volumes are about 340000 tonnes in 2006-2007, over 340000 tonnes in 2007-2008, about 320000 tonnes in 2008-2009, over 320000 tonnes in 2009-2010 and about 170000 tonnes in 2010-2011 (Anonymous 2013).

*Vigna radiata* (L.) Wilczek. (mung bean) has been consumed as common food in China for more than 2000 years. It is well known for its detoxification activities and is used to refresh mentality, alleviate heat stroke, and reduce swelling in the summer. Mung beans contain balanced nutrients, including protein and dietary fiber, and significant amounts of bioactive phytochemicals. Mung beans to be the main contributors to the antioxidant, antimicrobial, anti-inflammatory and antitumor activities (Tang *et al.* 2014).

The petiole of *Vigna radiata* (L.) Wilczek. is irregular shape and the epidermal cells is uniseriate with rectangular shaped cells and covered with simple, unicellular and unbranched trichomes. One layer of circular collenchymas cells is located under the epidermis. The cortex consists of orbicular parenchymatous cells. The stele is clearly divided into large two adaxial bundles and smaller three abaxial bundles forming main trace and collateral type. The pith is composed of polygonal parenchymatous cells with intercellular space. In transverse section of leaves, the upper and lower leaf epidermis layers are composed of uniseriate with rectangular cells and buliform. The type of stomata observed is paracytic and they occur on the surface of both sides being more abundant on the lower surface. The midrib is well developed and vascular bundles are collateral type (Siapoosh *et al.* 2015).

The transverse section of the stem of *Vigna radiata* (L.) Wilczek. is ribbed. The stele consists of collateral vascular bundles arranged in a ring that separated from one another by interfascicular cambium (Siapoosh *et al.* 2015).

Anatomical structure is most likely to provide evidence concerning the interrelationships of larger groups such as families, or in helping to establish the real affinities of genera of uncertain taxonomic status. Anatomy sometimes proves very helpful for individual identification. For example, microscopical methods are of great value in establishing the identity of herbarium specimens which are not accompanied by flower or fruits (Metcalf & Chalk 1979).

Various medicinal uses and planting techniques of mung bean were studied by other researchers. However, the anatomical study of *Vigna radiata* (L.) Wilczek. is scanty. It is for this reasons, it is needed to study morphological and anatomical charactersitics of *Vigna radiata* (L.) Wilczek.

The aims and objectives of this research are to study and describe the morphological and anatomical characters of leaves, stems and roots of *Vigna radiata* (L.) Wilczek. and to provide the specific information of morphological and anatomical characteristics for identification.

## **Materials and Methods**

The specimens of *Vigna radiata* (L.) Wilczek. were collected from Myingyan Township, Mandalay Region from June to December 2016. The collected specimens were studied and identified in Department of Botany, University of Mandalay with the help of literatures Backer (1965), Hooker (1883), Dassanayake (1991), Qi-ming & Nian-he (2008) and Zhengyin & Raven (2013).

After the collection, some of the specimens were studied in fresh stage and others were pressed and dried at room temperature as well as preserved in 50% ethyl alcohol for further study.

After killing and fixation, the small portions of leaves, stems and roots were thoroughly washed in running water for overnight and dehydrated through a series of tertiary butyl alcohol solutions. Then, they were infiltrated in a series of paraffin wax of which melting points were 49°C, 55 °C and 60°C respectively. They were kept in oven for overnight or 24 hours. The specimens were then embedded in the 60°C paraffin wax and cut into 15-25 µm thick sections by using a rotary microtome. These thin sections were double-stained with the combination of saffranin and fast green solutions. After staining, the sections were permanently

mounted under a cover slip with a Canada Balsam in xylol and kept dried for a few weeks on slide tray. The dehydration, infiltration, embedding, staining and mounting were made according to Johansen's method (1940). The parts of specimens were macerated by warming in equal volume of 50% hydrogen peroxide solution and 50% glacial acetic acid solution according to Jeffery's method (1917). The vessels elements, tracheids and fibers were studied and measured. The photomicrographs were also presented.

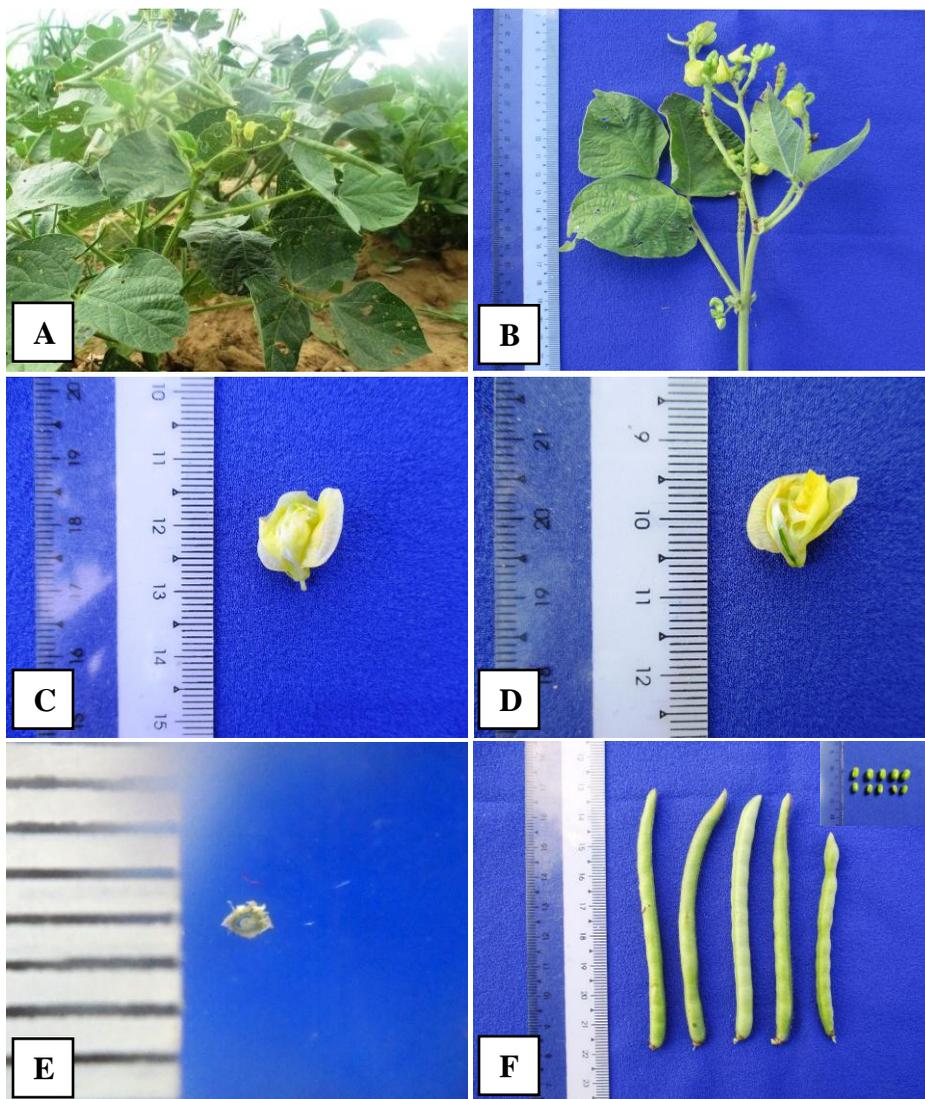
## Results

### Morphological studies

*Vigna radiata* (L.) Wilczek., Fl. Congo Belge 6: 386. 1954.

Family	-	Fabaceae
Sub- family	-	Papilionoideae
Myanmar Name	-	Pe tesein
English Name	-	Mung bean; green gram
Flowering period	-	June and July

Annual erect herbs, 35.0 – 50.0 cm high; stems and branches brown hirsute. Leaves pinnately trifoliolate compound, alternate; stipules ovate, 0.2 – 1.5 cm by 0.2 – 0.9 cm, dorsifixed, pubescent; petioles 1.6 – 18.5 cm long, pubescent; stipels lanceolate, 0.2 – 0.7 cm long, pubescent; leaflets ovate, entire along the margin, acuminate at the apex, sparsely pilose on both surfaces, cuneate or rounded at the base; terminal leaflets 2.7 – 10.7 cm by 2.1 – 9.6 cm; lateral leaflets 2.0 – 10.5 cm by 1.8 – 9.5 cm. Inflorescences axillary or terminal racemes; peduncles terete, 0.8 – 2.5 cm long, pubescent. Flowers bisexual, zygomorphic, cyclic, pentamerous, hypogynous, yellow; pedicel about 0.3 cm long, bracts ovate – lanceolate, 0.3 – 0.5 cm long, caducous; bracteoles linear, 0.3 – 0.6 cm long, persistent. Calyx campanulate, 5-lobed; tube 0.4 – 0.6 cm long, pubescent; lobes about 0.2 cm long, two lobes connate into a bifid one, pubescent. Corolla papilionaceous; standard orbicular, 1.0 – 1.3 cm by 1.4 – 1.7 cm, apex emarginated, without appendages, greenish yellow, glabrous; wings ovate, 1.5 – 1.8 cm by 0.4 – 0.7 cm, short clawed, yellow, glabrous; keels falcate, 1.3 – 2.0 cm by 0.4 – 0.9 cm, yellow, glabrous, beak incurved. Stamens 10 (9+1), diadelphous, free from the petals,



**Figure 1** Morphological characters of *Vigna radiata* (L.) Wilczek.

- A. Habit
- B. Inflorescence
- C. Flower
- D. L.S of flower
- E. T.S of ovary
- F. Fruits and Seeds

inserted; free filament filiform, 1.0 – 1.5 cm long, yellow, glabrous; anthers dithecal, dorsifixed, yellow, dehiscent longitudinally. Carpel 1; ovary superior, linear, 0.8 – 1.5 cm long, unilocular, many ovules in the locule on the marginal placentae, pubescent; style flat, 1.0 – 1.5 cm long, twisted, with long hairs below the stigma; stigma globose. Pods straight, turgid, 6.0 – 9.4 cm long, 0.3 – 0.5 in width, 8- to 13- seeded, dehiscent, sparsely pale brown hirsute. Seeds oblong – rounded, 0.3 – 1.0 cm by 0.2 – 0.6 cm, greenish or yellowish green, glabrous (Figure 1).

## **Anatomical Studies**

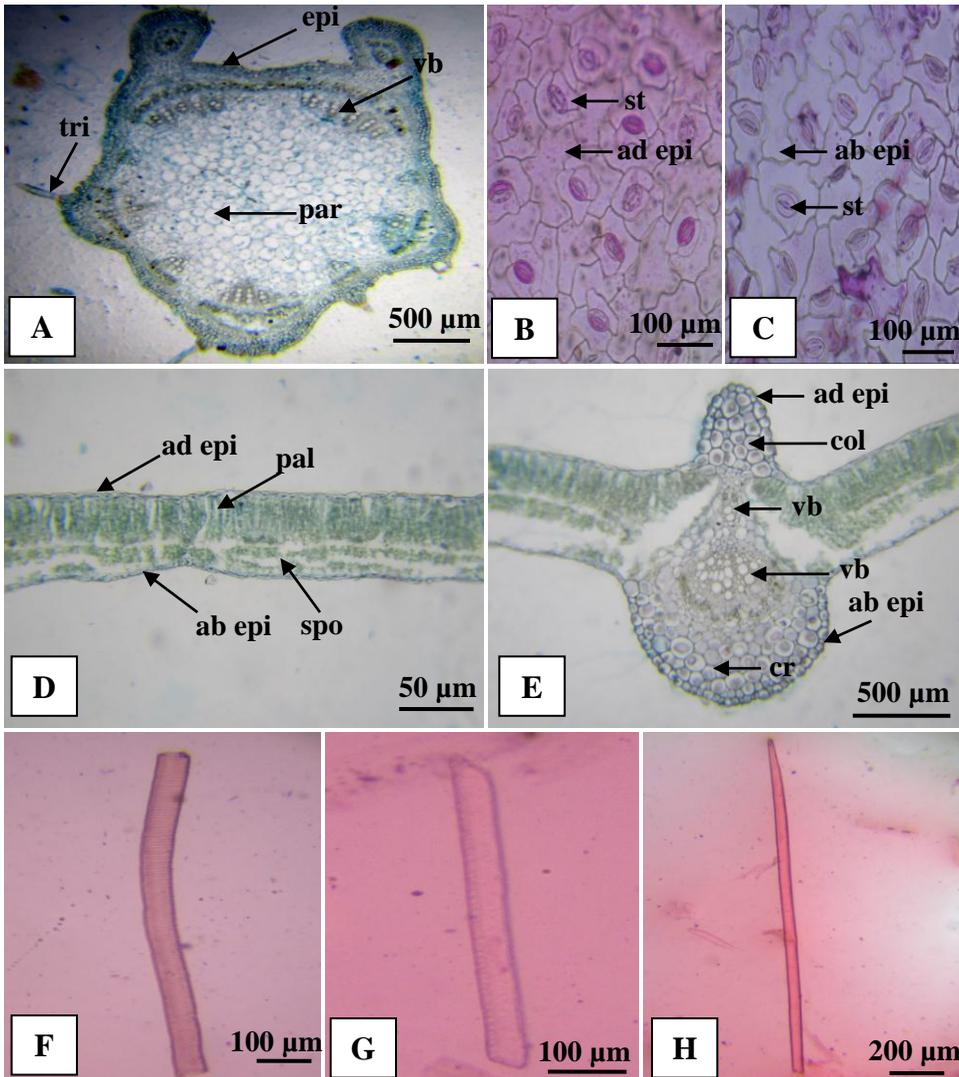
### **Internal structure of petiole (Figure 2 A)**

In transverse section, the petiole of *Vigna radiata* (L.) Wilczek. studied was oval shape in outline with prominent wing at the adaxial side, 1612.0 – 2062.5  $\mu\text{m}$  in length, 1437.5 – 2000.0  $\mu\text{m}$  in width. Distinguishable into dermal, ground and vascular tissue systems (Figure 2 A).

**Dermal Tissue System:** Composed of epidermal cells. In transverse section, epidermis 1 - layered on both surfaces, cell barrel in shape, compact, 11.25 – 25.00  $\mu\text{m}$  in length 10.0 – 27.5  $\mu\text{m}$  in width, outer and inner wall convex, anticlinal walls straight.

**Ground Tissue System:** Composed of collenchymatous and parenchymatous tissues. Collenchymatous cells 2 to 5 - layered, the layers 35.0 – 100.0  $\mu\text{m}$  thick, cells polygonal in shape, 10.0 – 32.5  $\mu\text{m}$  in length, 10.0 – 33.75  $\mu\text{m}$  in width; parenchymatous cells below the collenchymatous cells, 3 to 6 - layered, the layers 56.25 – 112.5  $\mu\text{m}$  thick, cells oval or rounded in shape, 11.25 – 23.75  $\mu\text{m}$  in length, 15.0 – 26.25  $\mu\text{m}$  in width, intercellular spaces present.

**Vascular Tissue System:** Vascular bundles embedded in the ground tissue, bundles arranged in a ring, consists of 5 large bundles alternate with 4 small bundles, collateral type, accompanied by 2 accessory bundles present in adaxial 2 lateral prominent wings, each bundle oval in shape, 125.0 – 312.5  $\mu\text{m}$  in length, 125.0 – 687.5  $\mu\text{m}$  in width; phloem lying outside and xylem lying inside; phloem composed of 4 to 8 -layered, the



**Figure 2 Internal structures of leaves of *Vigna radiata* (L.) Wilczek.**

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| A. T.S of petiole                 | B. Adaxial surface view of lamina |
| B. Abaxial surface view of lamina | D. T. S of lamina                 |
| E. T.S of midrib                  | F. Vessel element                 |
| G. Tracheary element              | H. Fibre                          |

(ab epi = abaxial epidermal cell, ad epi= adxial epidermal cell, col = collenchyma cell, cr = cortex, epi= epidermal cell, par = parenchyma cell, pal = palisade parenchyma cell, ph = phloem, spo= spongy parenchyma cell, st = stoma, vb= vascular bundle, xy = xylem)

layers 31.25 – 68.75  $\mu\text{m}$  thick, cells polygonal in shape, 6.25 – 11.25  $\mu\text{m}$  in radial diameter, 3.75 – 11.25  $\mu\text{m}$  in tangential diameter, phloem composed of sieve tubes, companion cells, phloem parenchyma cells and phloem fibres; xylem composed of 1 to 4 -layered, the layers 20.0 – 125.0  $\mu\text{m}$  thick, cells polygonal in shape, 12.5 – 37.5  $\mu\text{m}$  in radial diameter, 10.0 – 37.5  $\mu\text{m}$  in tangential diameter, xylem composed of vessel elements, tracheids, xylem parenchyma and xylem fibres. Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickening spiral or scalariform, perforation plates simple, 65.0 – 650.0  $\mu\text{m}$  (mean 271.0  $\mu\text{m}$ ) in length, 10.0 – 75.0  $\mu\text{m}$  (mean 30.3  $\mu\text{m}$ ) in width; tracheids elongate, lateral walls straight, end walls bluntly acute, thickenings spiral, 50.0 – 320.0  $\mu\text{m}$  (mean 138.0  $\mu\text{m}$ ) in length, 10.0 – 50.0  $\mu\text{m}$  (mean 18.6  $\mu\text{m}$ ) in width; fibres long, lateral walls straight, end walls acute, 250.0 – 3175.0  $\mu\text{m}$  (mean 1190.0  $\mu\text{m}$ ) in length, 10.0 – 40.0  $\mu\text{m}$  (mean 23.2  $\mu\text{m}$ ) in width, the pits slit-like; xylem parenchyma cells rectangular or irregular rectangular, pits simple.

### **Internal structure of lamina (Figure 2 B - D)**

In transverse section, the lamina of *Vigna radiata* (L.) Wilczek. studied was dorsiventral with reticulate venation, 175.0 – 220.0  $\mu\text{m}$  thick. Distinguishable into dermal, ground and vascular tissue systems.

**Dermal Tissue System:** Composed of epidermal cells, guard cells of stomata, subsidiary cells and trichomes. In surface view, adaxial epidermal cells parenchymatous, polygonal in shape, 22.5 – 82.5  $\mu\text{m}$  in length, 18.75 – 77.5  $\mu\text{m}$  in width, cell walls wavy; abaxial epidermal cells parenchymatous, polygonal in shape, 18.75 – 100.0  $\mu\text{m}$  in length, 13.75 – 81.25  $\mu\text{m}$  in width, cell walls more wavier than adaxial cells; stomata paracytic type; guard cells on adaxial surface 21.25 – 30.0  $\mu\text{m}$  in length, 18.75 – 77.5  $\mu\text{m}$  in width; guard cells on abaxial surface 18.75 – 31.25  $\mu\text{m}$  in length, 5.0 – 8.75  $\mu\text{m}$  in width; subsidiary cells on adaxial surface 27.5 – 70.0  $\mu\text{m}$  in length, 6.25 – 22.5  $\mu\text{m}$  in width; subsidiary cells on abaxial surface 25.0 – 77.5  $\mu\text{m}$  in length, 2.5 – 21.25  $\mu\text{m}$  in width. In transverse section, both upper and lower epidermis 1- layered; adaxial epidermal cells barrel shaped, 7.5 – 18.75  $\mu\text{m}$  in length, 10.0 – 62.5  $\mu\text{m}$  in width, anticlinal walls straight, outer and inner walls convex; abaxial epidermal cells barrel shaped, 8.75 – 21.25  $\mu\text{m}$  in length, 18.75 – 31.25  $\mu\text{m}$  in width,

anticlinal walls straight, outer and inner walls convex; cuticle thin on both surfaces.

**Ground Tissue System:** Mesophyll differentiated into palisade and spongy parenchyma. Palisade parenchyma 2 or 3 - layered, the layers 62.5 – 87.5  $\mu\text{m}$  thick, cells elongated, 22.5 – 40.0  $\mu\text{m}$  in length, 6.25 – 12.5  $\mu\text{m}$  in width, compact; spongy parenchyma 2 to 6 -layered, the layers 65.0 – 90.0  $\mu\text{m}$  thick, cells oval or rounded in shape, 6.25 – 16.25  $\mu\text{m}$  in length, 6.25 – 20.0  $\mu\text{m}$  in width, chloroplast abundant, intercellular spaces present.

**Vascular Tissue System:** Vascular bundles of lateral veins were embedded in the mesophyll tissues. They were collateral type and different in size according to their position; bundle sheath distinct and composed of parenchymatous cells, rounded or oval in shape. Phloem composed of sieve tubes, companion cells, phloem parenchyma and phloem fibres; xylem composed of vessel elements, tracheids, xylem parenchyma and xylem fibres. Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickening spiral or scalariform, perforation plates simple, 70.0 – 260.0  $\mu\text{m}$  (mean 157.0  $\mu\text{m}$ ) in length, 10.0 – 45.0  $\mu\text{m}$  (mean 27.2  $\mu\text{m}$ ) in width; tracheids elongate, lateral walls straight, end walls bluntly acute, thickenings spiral, 10.0 – 200.0  $\mu\text{m}$  (mean 78.0  $\mu\text{m}$ ) in length, 10.0 – 400.0  $\mu\text{m}$  (mean 89.5  $\mu\text{m}$ ) in width; fibres long, lateral walls straight, end walls acute, 390.0 – 1425.0  $\mu\text{m}$  (mean 690.0  $\mu\text{m}$ ) in length, 15.0 – 35.0  $\mu\text{m}$  (mean 22.7  $\mu\text{m}$ ) in width, the pits slit-like; xylem parenchyma cells rectangular or irregular in shape, pits simple.

### **Internal structure of midrib (Figure 2 E)**

In transverse section, the midrib of *Vigna radiata* (L.) Wilczek. studied was oval shaped in outline, with convex at the abaxial side and prominent protrude at the adaxial side, 937.5 – 1087.5  $\mu\text{m}$  in radial diameter, 562.5 – 812.5  $\mu\text{m}$  in tangential diameter. Distinguishable into dermal, ground and vascular tissue system.

**Dermal Tissue System:** Composed of epidermal cells and trichomes. In transverse section, both upper and lower epidermis 1- layered, cells barrel shaped, 15.0 – 36.25  $\mu\text{m}$  in length, 6.25 – 43.75  $\mu\text{m}$  in width, outer and inner walls convex, anticlinal walls straight.

**Ground Tissue System:** Composed of collenchymatous and parenchymatous tissues. Collenchymatous cells below the adaxial epidermis 3 to 6 - layered, the layers 115.0 – 250.0  $\mu\text{m}$  thick, cells polygonal in shape, compact, 21.25 – 46.25  $\mu\text{m}$  in length, 25.0 – 47.5  $\mu\text{m}$  in width; collenchymatous cells above the abaxial epidermis 1 or 2 - layered, the layers 25.0 – 40.0  $\mu\text{m}$  thick, cells polygonal in shape, 18.75 – 37.50  $\mu\text{m}$  in length, 75.00 – 33.75  $\mu\text{m}$  in width; parenchymatous cells above the vascular bundle, 4 to 6 - layered, the layers 50.0 – 75.0  $\mu\text{m}$  thick, cells oval or rounded in shape, 10.0 – 35.0  $\mu\text{m}$  in length, 8.75 – 31.25  $\mu\text{m}$  in width; parenchymatous cells below the vascular bundle, 3 to 5 - layered, the layers 125.0 – 150.0  $\mu\text{m}$  thick, cells oval or rounded in shape, 15.0 – 56.25  $\mu\text{m}$  in length, 35.0 – 66.25  $\mu\text{m}$  in width, intercellular spaces present.

**Vascular Tissue System:** Vascular bundles embedded in the ground tissue, composed of opposite systems of two bundles, with their xylem groups abutting on one another; phloem lying outside and xylem lying inside, collateral type. One large bundle situated above the abaxial side, oval in shape, 200.0 – 260.0  $\mu\text{m}$  in radial diameter, 225.0 – 410  $\mu\text{m}$  in tangential diameter; phloem 3 to 7 - layered, the layers 37.5 – 100.0  $\mu\text{m}$  thick, cells compact, 3.75 – 8.75  $\mu\text{m}$  in length, 3.75 – 8.75  $\mu\text{m}$  in width; xylem 2 to 6 - layered, the layers 50.0 – 175.0  $\mu\text{m}$  thick, cells polygonal in shape, 20.0 – 40.0  $\mu\text{m}$  in length, 15.0 – 35.0  $\mu\text{m}$  in width. One small bundle situated at the adaxial side, oval shaped, 100.0 – 150.0  $\mu\text{m}$  in radial diameter, 60.0 – 150.0  $\mu\text{m}$  in tangential diameter; phloem 3 to 6 - layered, the layers 31.25 – 75.0  $\mu\text{m}$  thick, cells compact, 3.75 – 8.75  $\mu\text{m}$  in length, 3.75 – 8.75  $\mu\text{m}$  in width; xylem 2 to 4 - layered, the layers 65.0 – 150.0  $\mu\text{m}$  thick, cells polygonal in shape, 15.0 – 30.0  $\mu\text{m}$  in length, 10.0 – 20.0  $\mu\text{m}$  in width. Phloem composed of sieve tubes, companion cells, phloem parenchyma cells and phloem fibres; xylem composed of vessel elements, tracheids, xylem parenchyma and xylem fibres. Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickening spiral or scalariform, perforation plates simple, 55.0 – 275.0  $\mu\text{m}$  (mean 147.5  $\mu\text{m}$ ) in length, 15.0 – 50.0  $\mu\text{m}$  (mean 29.7  $\mu\text{m}$ ) in width; tracheids elongate, lateral walls straight, end walls bluntly acute, thickenings spiral, 45.0 – 250.0  $\mu\text{m}$  (mean 128.0  $\mu\text{m}$ ) in length, 10.0 – 45.0  $\mu\text{m}$  (mean 18.6  $\mu\text{m}$ ) in width; fibres long, lateral walls straight, end walls acute, 300.0 – 1525.0  $\mu\text{m}$  (mean 690.0  $\mu\text{m}$ ) in length, 15.0 – 40.0  $\mu\text{m}$  (mean 24.35  $\mu\text{m}$ )

in width; xylem parenchyma cells rectangular or irregular in shape, pits simple.

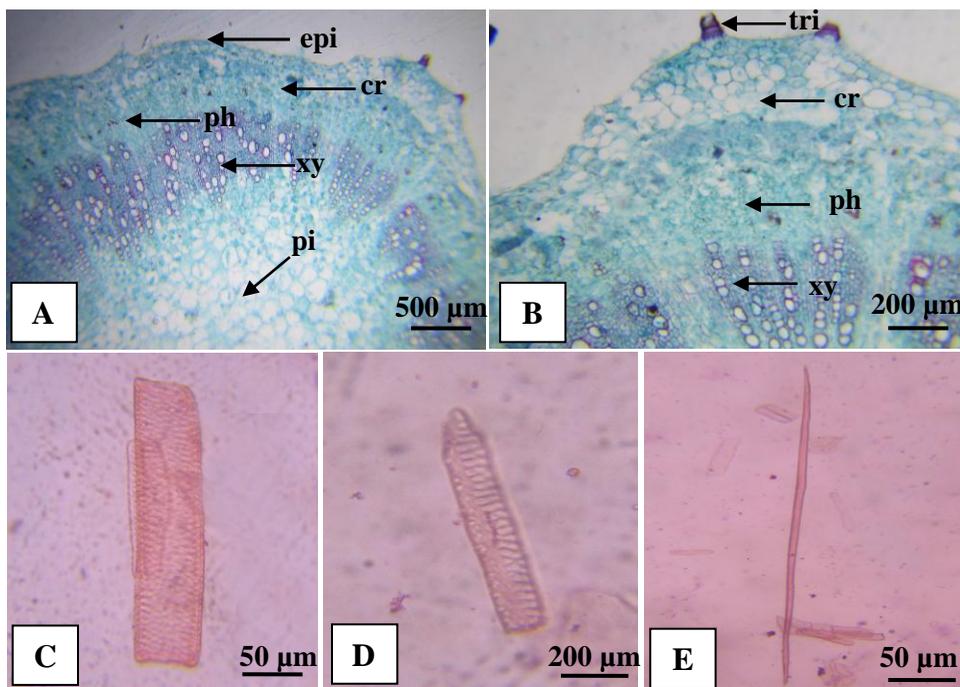
### **Internal structure of stem (Figure 3)**

In transverse section, the stem of *Vigna radiata* (L.) Wilczek. studied was circular in outline, 2937.5 – 3625.0 µm in length, 3875.0 – 5062.5 µm in width. Distinguishable into dermal, ground and vascular tissue systems.

**Dermal Tissue System:** In transverse section, epidermal cells 1- layered, cells oval or barrel in shape, 15.0 – 25.0 µm in length and 15.0 – 31.25 µm in width, outer wall convex, anticlinal walls straight; trichome uniseriate, 1 or 2-celled; cuticle thin.

**Ground Tissue System:** Composed of cortex, endodermis, pericycle and pith. The cortex differentiated into outer collenchymatous tissue and inner parenchymatous tissue. Collenchymatous cells forming a continuous sheath, 1 to 7 - layered, the layers 25.0 – 250.0 µm thick, the cells polygonal or oval in shape, 12.5 – 50.0 µm in length, 18.75 – 62.5 µm in width, thickening angular. Parenchymatous cells occur below the collenchymatous cells, 5 to 13 - layered, the layers 85.0 – 275.0 µm thick, the cells rounded or oval shaped, 10.0 – 50.0 µm in length, 17.5 – 50.0 µm in width, intercellular space present. Endodermis and pericyclic layer is inconspicuous. Pith cellular large, 2875.0 – 3750.0 µm in diameter, the cells parenchymatous, oval or rounded or polygonal in shape, 35.0 – 150.0 µm in length, 40.0 – 200.0 µm in width, thin-walled, intercellular spaces present.

**Vascular Tissue System:** Vascular bundles embedded in the ground tissue and arranged in a continuous circular ring, collateral type, the bundles 250.0 – 1125.0 µm thick; phloem lying outside and xylem lying inside; phloem 4 to 13 - layered, the layers 22.5 - 100 µm thick, the cells oval or irregular in shape, 5.0 – 12.5 µm in length, 8.75 – 10.0 µm in width, phloem composed of sieve-tube elements, companion cells, phloem parenchyma and phloem fibres; xylem arranged in radial rows, 1 to 6 - layered, the layers 30.0 – 200.0 µm thick, the cells rounded or polygonal in shape, 13.75 – 43.75 µm in length, 7.5 – 37.5 µm in width, xylem composed of vessel elements, tracheids, fibres and xylem parenchyma.



**Figure 3** Internal structure of stem of *Vigna radiata* (L.) Wilczek.

- A. Transverse section of stem
- B. Close up view cortex layer and vascular bundle
- C. Vessel element
- D. Tracheary element
- E. Fibre

(cr= cortex, epi= epidermis, pi = pith, ph= phloem, tri=trichome, xy = xylem)

Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickening spiral or scalariform, perforation plates simple, 70.0 – 425.0  $\mu\text{m}$  (mean 237.0  $\mu\text{m}$ ) in length, 20.0 – 75.0  $\mu\text{m}$  (mean 42.0  $\mu\text{m}$ ) in width; tracheids elongate, lateral walls straight, end walls bluntly acute, thickenings spiral, 75.0 – 450.0  $\mu\text{m}$  (mean 164.5  $\mu\text{m}$ ) in length, 10.0 – 30.0  $\mu\text{m}$  (mean 18.2  $\mu\text{m}$ ) in width; fibres long, lateral walls straight, end walls acute, 350.0 – 2500.0  $\mu\text{m}$  (mean 785.0  $\mu\text{m}$ ) in length, 10.0 – 25.0  $\mu\text{m}$  (mean 16.9  $\mu\text{m}$ ) in width, the pits slit-like; xylem parenchyma cells rectangular or irregular in shape, pits simple.

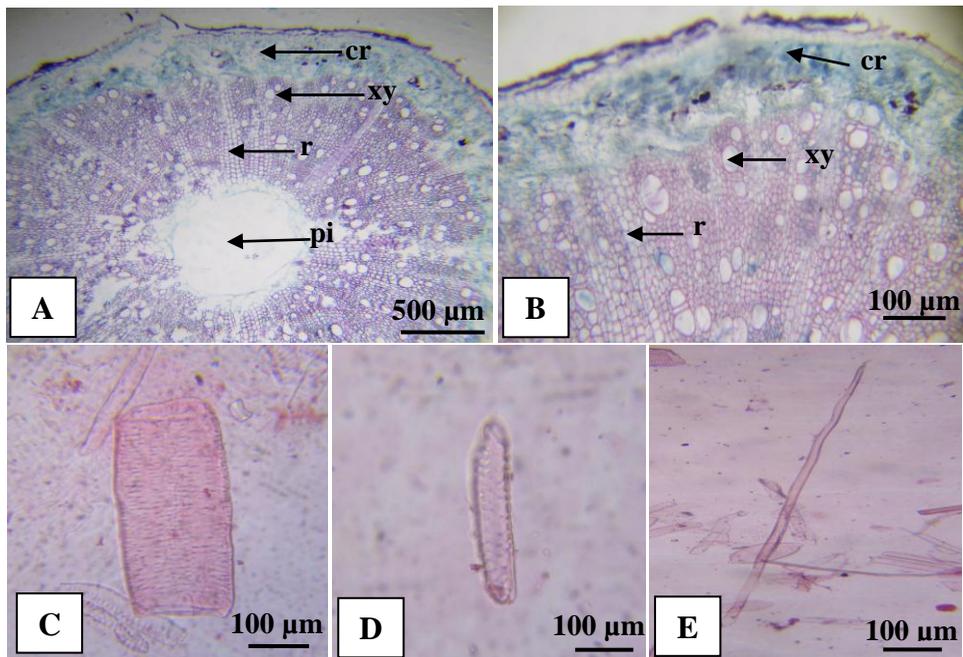
#### **Internal structure of root (Figure 4)**

In transverse section, the root of *Vigna radiata* (L.) Wilczek. studied was circular in outline, 1687.5 – 3625.0  $\mu\text{m}$  in length, 1812.5 – 3437.0  $\mu\text{m}$  in width. Distinguishable into dermal, ground and vascular tissue systems.

**Dermal Tissue System:** The epiblema 3 to 4 - layered, the layers 15.0 – 56.25  $\mu\text{m}$  thick, parenchymatous, the cells irregularly rectangular in shape, 8.75 – 33.75  $\mu\text{m}$  in length, 20.0 – 81.25  $\mu\text{m}$  in width.

**Ground Tissue System:** Composed of cortex, endodermis and pericycle. Cortex homogenous parenchymatous cells, 4 to 14 - layered, the layers 115.0 – 350.0  $\mu\text{m}$  thick, parenchymatous, cells oval or barrel or irregular in shape, 7.5 – 27.5  $\mu\text{m}$  in length, 10.0 – 50.0  $\mu\text{m}$  in width. Endodermis and pericyclic layers are inconspicuous. In the central portion of vascular strand, hollow pith present, 375.0 – 1050 in diameter.

**Vascular Tissue System:** Vascular bundles occurs as radial type, vascular cylinder tetrarch to polyarch, the bundle 562.5 – 1662.5  $\mu\text{m}$  thick; phloem distributed at the periphery of the xylem, 8 to 17 - layered, the layers 300.0 – 525.0  $\mu\text{m}$  thick, the cells 15.0 – 35.0  $\mu\text{m}$  in length, 10.0 – 15.0  $\mu\text{m}$  in width; xylem strands, 400.0 – 800.0 thick, cells polygonal or rounded in shape, 15.0 – 95.0  $\mu\text{m}$  in length, 15.0 – 80.0  $\mu\text{m}$  in width; phloem composed of sieve-tube elements, companion cells, phloem parenchyma and phloem fibres; xylem composed of vessel elements, tracheids, fibres and xylem parenchyma. Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickening spiral or scalariform, perforation plates simple, 75.0 – 245.0  $\mu\text{m}$  (mean 156.5  $\mu\text{m}$ ) in length, 25.0 – 160.0  $\mu\text{m}$  (mean 100.5  $\mu\text{m}$ ) in width; tracheids elongate, lateral walls straight, end walls bluntly acute, thickenings spiral, 75.0 – 340.0  $\mu\text{m}$  (mean 153.5  $\mu\text{m}$ ) in length, 10.0 – 40.0  $\mu\text{m}$  (mean 21.0  $\mu\text{m}$ ) in width; fibres long, lateral walls straight, end walls acute, 350.0 – 257.0  $\mu\text{m}$  (mean 825.0  $\mu\text{m}$ ) in length, 10.0 – 25.0  $\mu\text{m}$  (mean 14.7  $\mu\text{m}$ ) in width, the pits slit-like; xylem parenchyma cells rectangular or irregular in shape, pits simple.



**Figure 4** Internal structure of root of *Vigna radiata* (L.) Wilczek.

- A. Transverse section of root
  - B. Close up view cortex and vascular bundle
  - C. Vessel element
  - D. Tracheary element
  - E. Fibre
- (cr= cortex, pi = pith, ph= phloem, r = ray, xy = xylem)

### Discussion and Conclusion

*Vigna radiata* (L.) Wilczek. is belonging to family Fabaceae (Subfamily Papilionoideae) were studied. The plants were observed an annual erect herb with brown hirsute. The leaves were ovate, leaf bases cuneate or rounded and leaves tips were acuminate. The surfaces of leaves were sparsely pilose. These characters were in agreement with those mentioned by Hooker (1879), Dassanayake (1991) and Qi-ming & Nian-he (2008).

The inflorescences were terminal and axillary racemes. The flowers were bisexual, zygomorphic, cyclic, hypogynous, pedicellate and

yellow colour. These characters were agreed with Qi-ming & Nian-he (2008).

The calyx were campanulate, 5 – lobed; corolla papilionaceous. The stamens were diadelphous, free from the tepals and inserted, anthers ditheous, dorsifixed, dehiscing longitudinally. The ovaries were superior, linear, unilocular, marginal placentae. The fruits were dehiscent. These characters were agreed with those mentions by Hooker (1879), Dassanayake (1991) and Qi-ming & Nian-he (2008).

In anatomical characteristics of petioles, laminae, midribs, stems and roots were composed of dermal tissue system, ground tissue system and vascular tissue system.

In transverse section, petioles were oval shape in outline with prominent wing at the adaxial side. Vascular bundles arranged in a ring, collateral type, accompanied by 2 accessory bundles present in adaxial 2 lateral prominent wings. These characters were agreed with Metcalfe & Chalk (1950).

In surface view of laminae, stomata were paracytic type, these characters were in agreement with Metcalfe & Chalk (1950) and Siapoosh *et al.* (2015).

In transverse section, midribs were oval shaped in outline with prominently protrude in adaxial side. The two vascular bundles were observed, one large bundle and one small bundles lying opposite each other with their xylem groups abutting on one another. These characters were accordant with Metcalf and Chalk (1950) and Nassar (2013).

In transverse section, stems were circular in outline with wavy ridges. Pith cellular large and composed of thin walled parenchymatous cell. The vascular bundles were collateral type. These characters were in agreement with Metcalfe & Chalk (1950) and Siapoosh *et al.* (2015).

In the transverse section of root, epiblema was 3 or 4 - layered, parenchymatous; ground tissue system composed of cortex, endodermis and pericycle. The cortex composed of homogenous parenchymatous cells. The endodermis and pericycle was inconspicuous. The vascular tissue system was radial type, tetrarch to polyarch, phloem alternate with the xylem strands. Hollow pith was observed in the centre of root. These characters were agreed with Metcalf & Chalk (1950) and Nassar (2013).

In conclusion, the present research can provide the information of morphological and anatomical characters of *Vigna radiata* (L.) Wilczek. It is hoped that these finding were useful in species confirmation. The

position of vascular bundles in petioles and midribs will provide the useful for the diagnostic characters of identification of this plant.

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