

Title	Morphological and Anatomical characteristics of <i>Pisum sativum</i> L.
All Authors	May Zin Oo and Win Win Khaing
Publication Type	Local publication
Publisher (Journal name, issue no., page no etc.)	Mandalay University Research Journal, Vol.9, No. 2
Abstract	<i>Pisum sativum</i> L. belonging to family Fabaceae were collected from Amarapura Township, Mandalay Region. Morphological and anatomical characteristics were studied at the Department of Botany, University of Mandalay in the year of 2018. The morphological and anatomical characteristics of leaves, stems and roots were studied, described, discussed with their photographs and photomicrographs. In the morphological characteristics, the leaves were unipinnately paripinnate compound with terminal tendril, foliaceous stipules and the flowers were papilionaceous. In the anatomical characteristics, hollow pith was observed in transverse sections of petioles and stems. The vascular bundles of leaves and stems were collateral type. In the primary body of stem, vascular bundles were anomalous structure and arranged in two rings. The vascular bundles of root were radial type and triarch in primary body and polyarch in secondary body.
Keywords	<i>Pisum sativum</i> L., Morphological, Anatomical
Citation	
Issue Date	2018

Morphological and Anatomical characteristics of *Pisum sativum* L.

May Zin Oo¹ & Win Win Khaing²

Abstract

Pisum sativum L. belonging to family Fabaceae were collected from Amarapura Township, Mandalay Region. Morphological and anatomical characteristics were studied at the Department of Botany, University of Mandalay in the year of 2018. The morphological and anatomical characteristics of leaves, stems and roots were studied, described, discussed with their photographs and photomicrographs. In the morphological characteristics, the leaves were unipinnately paripinnate compound with terminal tendril, foliaceous stipules and the flowers were papilionaceous. In the anatomical characteristics, hollow pith was observed in transverse sections of petioles and stems. The vascular bundles of leaves and stems were collateral type. In the primary body of stem, vascular bundles were anomalous structure and arranged in two rings. The vascular bundles of root were radial type and triarch in primary body and polyarch in secondary body.

Key words: *Pisum sativum* L., Morphological, Anatomical

Introduction

Leguminosae family is also known as Fabaceae, and both term can be used to indicate the 690 genera and 18000 species. The Leguminosae family is classified into three sub-family; Papilionoideae, Caesalpinoideae and Mimosoideae. Each subfamily is defined by its flowers. Edible legume crops are mainly found in the subfamily Papilionoideae (Morris 2003).

The most famous pea is the garden pea, *Pisum sativum* L. which Gregor Mendel used for famous genetic experiments (Levetin & McMahan 2012). The legumes are a very large group of plants second only to the cereals as a source of food for man and animals. (Hagenblad *et al.* 2014).

Pisum sativum L. is a cool-season annual vine that is smooth and has a bluish-green waxy appearance. Vines can be up to 9 ft long, however modern cultivars have shorter vines, about 2 ft long. The stem is hollow, and the taller cultivars cannot climb without support. Leaves are alternate, pinnately compound, and consist of two large leaflike stipules, one to several pairs of oval leaflets, and terminal tendrils (Pavek 2012).

Investigation on chromosomal constitution and principal compounds of *Pisum sativum* L. grown in north western Myanmar was done by Kyi Kyi Win (2008). Taxonomy and pollen morphology of Fabaceae was done by Thin Thin Aye (2014). However, morphological and anatomical characteristics of *Pisum sativum* L. had not been studied yet. It is for this reasons, it is needed to study morphological and anatomical characteristics of *Pisum sativum* L.

The aims and objectives of this research are to study the morphological and anatomical characteristics of *Pisum sativum* L., to provide the qualitative and quantitative anatomical characteristics for species confirmation.

¹MSc student, Department of Botany, University of Mandalay

²Dr, Lecturer, Department of Botany, University of Mandalay

Materials and Methods

Pisum sativum L. were collected from from Shankalay Kyun village, Amarapura Township, Mandalay Region in the year of 2018. For morphological studies, the collected specimens were identified by using Backer & Brink (1960), Hooker (1885) and Dassanayake (1991) at the Department of Botany, University of Mandalay. 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.

For anatomical studies, the plant specimens were cut into 15-20 µm thick sections by using a rotary microtome and these thin sections were prepared a permanent slide. For microtome sections, Johansen's method (1940) and maceration of the specimens were done by using Jeffery's method (1917). The photomicrographs were also presented.

Results

1. Morphological studies

1.1 *Pisum sativum* L. Sp. Pl. 2: 727. 1753.

Myanmar Name : Sa daw pe

English Name : Garden pea

Annual small, climbing herbs up to 50 cm height, stems and branches, hollow, glabrous. Leaves unipinnately compound, paripinnate, alternate; stipules foliaceous, subcordate, about 1.9 - 2.3 cm long by 1.3 - 1.7 cm wide, persistent, glabrous; petioles 2.0 - 5.6 cm long, glabrous; petiolules about 0.1 cm long; leaflets 4 – 6 with terminal tendrils; leaf blade obovate, 1.9 - 3.4 cm long by 1.2 - 2.1 cm wide, cuneate at the base, entire along the margin, acute at the apex, glabrous. Inflorescences axillary cyme, 1- to 2- flowered; peduncles 0.4 - 2.3 cm long, cylindrical, glabrous. Flowers bisexual, zygomorphic, hypogynous, white, 0.8 - 0.9 cm long in diameter; pedicels 0.3 - 1.0 cm long, glabrous; bracts lanceolate, 0.2 - 0.3 cm long, persistent; bracteoles filiform, about 1.0 cm long; calyx 3-lobed, unequal, about 0.9 - 1.0 cm long, glabrous; corolla papilionaceous, standard ovate, 1.0 - 1.7 cm long, white, glabrous; wing ovate, 0.9 - 1.5 cm long; keel oblong or obovate, 0.6 - 1.0 cm long. Stamens 10 (9+1), diadelphous, free filament filiform, 0.8 - 1.2 cm long, anther dithecous, dorsifixed, dehiscing longitudinally. Carpels 1, ovary superior, oblong, 1.0 - 1.3 cm long; style slightly flattened; stigma slightly flattened, yellow. Pod oblong, 3.2 - 4.0 cm long, 2- to 6- seeded, dehiscing longitudinal slit; seeds rounded, glabrous, pale white when mature.

Specimen examined: Mandalay Region, Amarapura Township, Shankalay Kyun village; 26 February, 2018; May Zin Oo, collection no.6.

2. Anatomical studies

2.1 Internal structure of the leaves of *Pisum sativum* L. (Figure 2)

Petiole

In transverse section, petiole of *Pisum sativum* L. studied was quadrangular-shaped in outline, 1500.0 – 3375.0 µm in length and 1250.0 – 2625.0 µm in width, distinguishable into dermal, ground and vascular tissue systems.

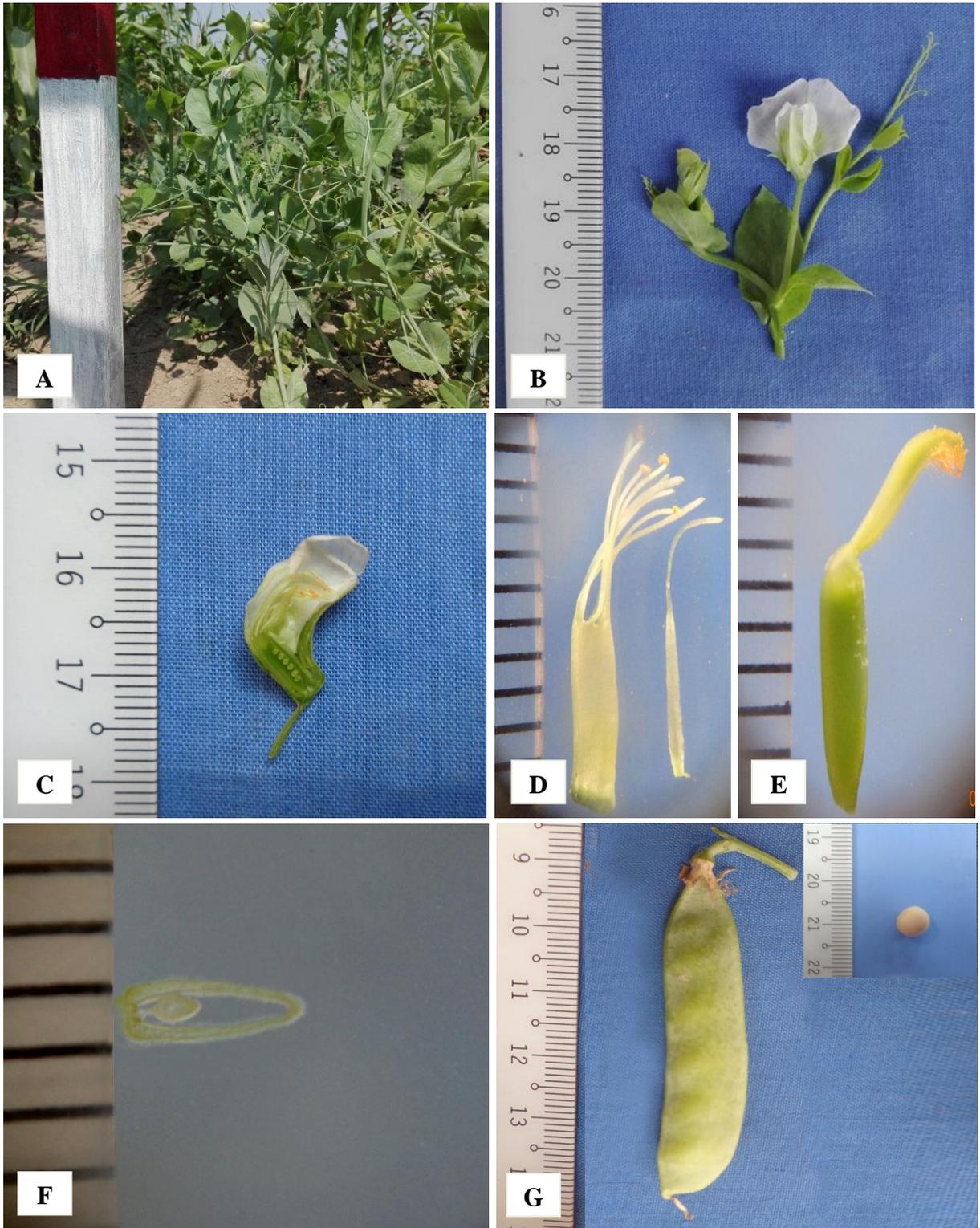


Figure 4.1 Morphological characteristics of *Pisum sativum* L.

- | | |
|-------------------|------------------|
| A. Habit | B. Inflorescence |
| C. L. S of Flower | D. Androecium |
| E. Gynoecium | F. T. S of ovary |
| G. Pod and seed | |

Dermal Tissue System: Composed of epidermal cells and trichomes. In transverse section, both upper and lower epidermis 1-layered, parenchymatous, the cells oval or rounded in shape, 20.0 – 40.0 μm in length, 10.0 – 20.0 μm in width, outer and inner walls convex, anticlinal walls straight.

Ground Tissue System: Differentiated into collenchymatous and parenchymatous tissues and cortex hollow; collenchymatous tissue composed of 2-layered, the layers 20.0 – 40.0 μm thick, the cell oval or polygonal in shape, 20.0 – 40.0 μm in diameter; parenchymatous tissue composed of 4- to 6-layered, the layers 220.0 – 500.0 μm thick, the cells polygonal in shape, 30.0 – 90.0 μm in diameter.

Vascular Tissue System: Vascular bundles embedded in the ground tissues, the bundles arranged in a circular ring, consists of 11 bundles, each bundle collateral type, oval-shaped, 180.0 – 400.0 μm in length and 60.0 – 180.0 μm in width; phloem lying outside side and xylem lying inside. Phloem composed of 3- to 6-layered, the layers 30.0 – 90.0 μm thick and composed of sieve tube elements and companion cells, phloem fibres and phloem parenchyma; xylem composed of 2- to 4-layered, the layers 70.0 – 140.0 μm thick and composed of vessels elements, tracheids, xylem fibres and xylem parenchyma. Vessels were measured 120.0 – 620.0 μm (mean 33907.8 μm) in length, 10.0 – 50.0 μm (mean 22.8 μm) in width. Tracheids were measured 130.0 – 1050.0 μm (mean 307.2 μm) in length, 10.0-630.0 μm (mean 26.2 μm) in width. Fibers were measured 400.0 – 3240.0 μm (mean 1222.0 μm) in length, 10.0 – 60.0 μm (mean 16.6 μm) in width.

Lamina

In transverse section, lamina of *Pisum sativum* L. studied was dorsiventral with reticulate venation, 120.0 – 290.0 μm thick.

Dermal Tissue System: In surface view, epidermal cells of both surfaces were parenchymatous, polygonal in shape, cell walls straight, thin-walled; adaxial epidermal cells 25.0 – 100.0 μm in length, 12.5 – 37.5 μm in width; abaxial cells 30.0 – 155.0 μm in length, 12.5 – 37.5 μm in width. Stomata present on the both surfaces, anomocytic type, oval shaped with reniform shaped guard cells. The guard cells 20.0 – 25.0 μm in length, 7.5 – 10.0 μm in width. In transverse section, both adaxial and abaxial epidermis composed of parenchymatous cells, 1-layered, the cells oval or barrel-shaped, 20.0 – 60.0 μm in length, 20.0 – 40.0 μm in width, outer and inner walls convex, anticlinal walls straight. Papillose present on adaxial epidermis. Cuticle thin on both surfaces.

Ground Tissue System: Mesophyll differentiated into palisade parenchyma at upper side and spongy parenchyma at the lower side; palisade cells 3- to 4-layered, 70.0 – 180.0 μm thick, the cells elongated in shape, cells compactly arranged; the spongy parenchyma cells 1- to 2-layered, the layers 50.0 – 130.0 μm thick, rounded to oval in shape, the cells 50.0 – 110.0 μm in length, 40.0 – 80.0 μm in width.

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. Xylem composed of vessels, tracheids, xylem fibers and xylem parenchyma. Vessels were measured 40.0 – 370.0 μm (mean 180.0 μm) in length, 5.0-30.0 μm (mean 11.2 μm) in width. Tracheids were measured 200.0 – 800.0 μm (mean 459.8 μm) in length, 5.0 – 10.0 μm (mean 8.4 μm) in width. Fibers were measured 300.0 – 1700.0 μm (mean 720.6 μm) in length, 5.0 – 10.0 μm (mean 7.5 μm) in width.

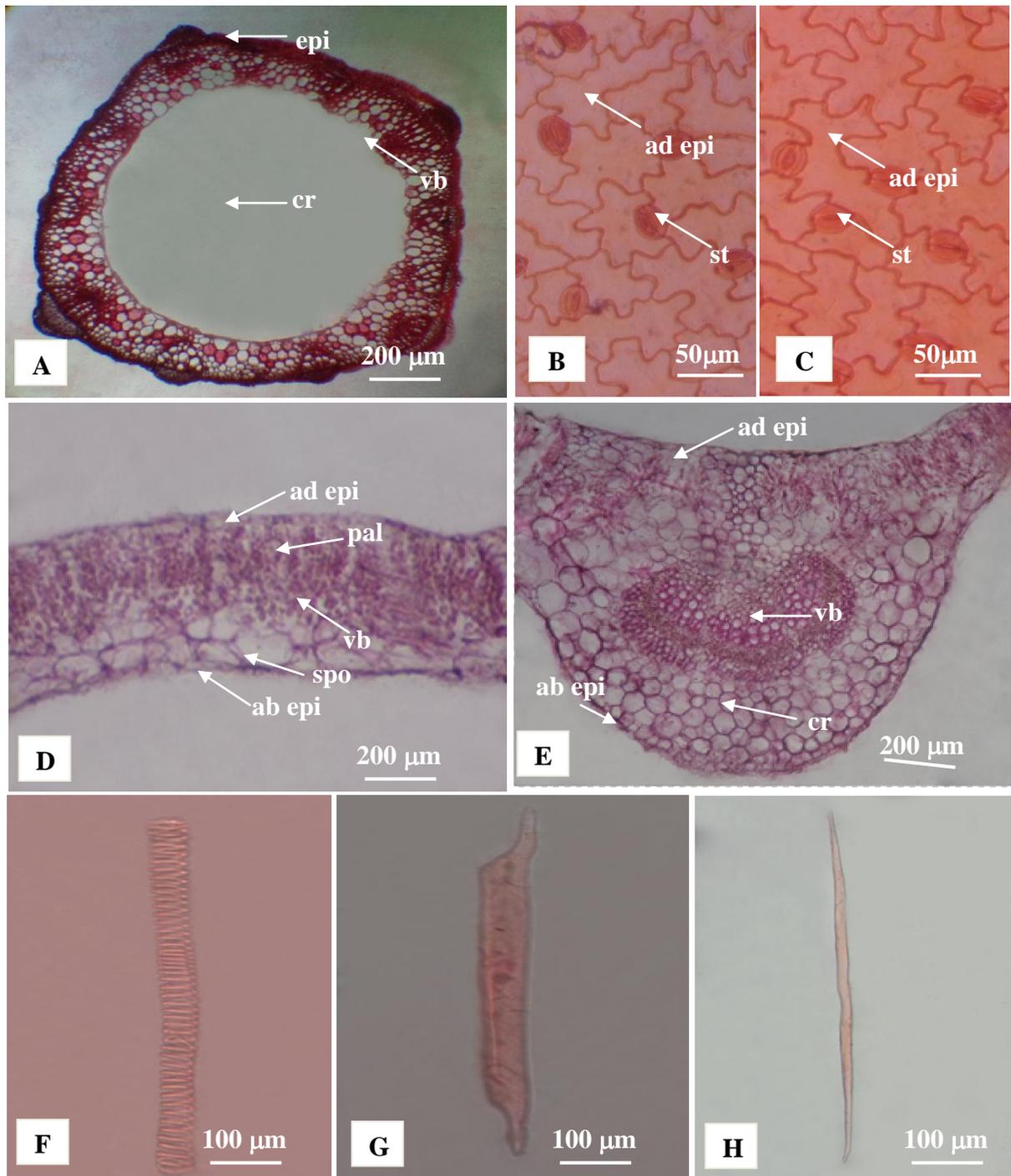


Figure 2 Internal structures of leaf of *Pisum sativum* L.

- A. T.S of petiole showing vascular bundles and hollow cortex
 B. Adaxial surface view of lamina. C. Abaxial surface view of lamina.
 D. T. S of lamina showing epidermal layer, palisade and spongy mesophyll cells. E. T. S of Midrib. F. Vessel element.
 G. Tracheid H. Fiber
 (ab epi = abaxial epidermal cell, ad epi = adaxial epidermal cell, cr = cortex, pal = palisade parenchyma cell, spo = spongy parenchyma cell, st = stoma, vb = vascular bundle)

Midrib

In transverse section, the midrib studied was semicircular in outline, prominent convex at the adaxial side, 1375.0 - 1750.0 μm in length and 1000.0 - 1200.0 μm in width.

Dermal Tissue System: Composed of epidermal cells, both upper and lower epidermis 1-layered, parenchymatous, the cell barrel-shaped, 10.0 – 50.0 μm in diameter, outer and inner walls convex, anticlinal wall straight.

Ground Tissue System: Composed of collenchymatous and parenchymatous tissues. Collenchymatous cells below the adaxial epidermis and above the abaxial epidermis 1- to 2-layered, the layers 40.0 – 50.0 μm thick, the cells oval or rounded in shape, 30.0 – 40.0 μm in length, 20.0 – 40.0 μm in width; parenchymatous cells above the vascular bundle, 8- to 14-layered, the layers 240.0 – 290.0 μm thick, the cell oval or rounded in shape, 30.0 – 80.0 μm in length, 20.0 – 60.0 μm in width; parenchymatous cells below the vascular bundle, 4- to 5-layered, the layers 15.0 – 25.0 μm thick, the cell oval or rounded in shape, 30.0 – 90.0 μm in diameter, intercellular spaces present.

Vascular Tissue System: The vascular bundle embedded in the ground tissues, the bundles arranged in crescent-shaped, consists of 3 bundles closely appressed to each other, each bundles collateral type, oval-shaped, 140.0 – 200.0 μm in length, 550.0 – 570.0 μm in width, xylem on the adaxial side and phloem on the abaxial side; phloem 6- to 9-layered, the layers 20.0 – 60.0 μm thick, phloem composed of sieve tubes, companion cells, phloem parenchyma and phloem fibres; xylem 2- to 5-layered, the layers 60.0 – 100.0 μm thick, the cell oval or rounded in shaped, 20.0 – 40.0 μm in diameter, xylem composed of vessel elements, tracheids, xylem parenchyma and xylem fibres. Vessels were measured 50.0 – 400.0 μm (mean 201.2 μm) in length, 10.0 – 40.0 μm (mean 18.2 μm) in width. Tracheids were measured 100.0 – 110.0 μm (mean 97.6 μm) in length, 10.0 – 40.0 μm (mean 19.4 μm) in width. Fibers were measured 140.0 – 2020.0 μm (mean 803.4 μm) in length, 10.0 – 30.0 μm (mean 14.0 μm) in width.

2.2 Internal structure of the stems of *Pisum sativum* L. (Figure 3)

Primary body

In transverse section, the stem was oval-shaped in outline, 1625.0 - 2900.0 μm in length and 1550.0 - 2800.0 μm in width, composed of dermal, ground and vascular tissue systems.

Dermal Tissue System: In transverse section, epidermis 1-layered, the cells oval to barrel shape, 30.0 – 40.0 μm in length, 10.0 – 40.0 μm in width outer and inner walls convex, anticlinal walls straight.

Ground Tissue System: Composed of cortex, endodermis, pericycle and pith. The cortex differentiated into outer collenchymatous tissue and inner parenchymatous tissue. The outer collenchymatous tissues composed of 2-layered, the layers 40.0 – 60.0 μm in thick, the cells oval in shape, 30.0 – 40.0 μm in diameter. The inner parenchymatous tissues composed of 8- to 16-layered, the layers 200.0 – 650.0 μm thick, the cells oval or rounded in shape, 30.0 – 60.0 μm in length, 30.0 – 50.0 μm in width, intercellular space present. Endodermis and pericycle inconspicuous. Pith absent.

Vascular Tissue System: Vascular bundles embedded in the ground tissues, the anomalous structure, the bundles arranged in two rings, the outer ring cortical vascular bundle consists of 4 bundles, the inner ring medullary vascular bundles consists of 4 to 6 bundles, each bundles collateral type, 100.0 – 250.0 μm in length, 150.0 – 200.0 μm in width; phloem outer and xylem inner; phloem 20.0 – 100.0 μm thick, the cells oval or irregular in shape, phloem composed of sieve tube elements, companion cells, phloem parenchyma and phloem fibres. Xylem arranged in radial rows, the layers 40.0 – 100.0 μm thick, the cells rounded or polygonal in shape, xylem composed of vessel elements, tracheids, xylem fibres and xylem parenchyma.

Secondary body

In transverse section, the stem was circular-shaped in outline, 1400.0 – 1450.0 μm in tangential diameter and 1150.0 – 1200.0 μm in radial diameter.

Dermal Tissue System: In transverse section, epidermis 1-layered, the cells oval to barrel in shape, 20.0 – 40.0 μm in diameter, outer and inner walls convex, anticlinal walls straight.

Ground Tissue System: Composed of cortex; outer collenchymatous tissues composed of 1- to 3-layered, the cells oval in shape, 10.0 – 30.0 μm in diameter; inner parenchymatous tissues composed of 5- to 8-layered, the cells oval or rounded in shape, 50.0 – 90.0 μm in length, 30.0 – 80.0 μm in width. Pith hollow.

Vascular Tissue System: Vascular bundles embedded in the ground tissue, the bundles arranged in a continuous circular ring, consists of 10 to 13 bundles, collateral type, phloem outer and xylem inner. Vessels were measured 90.0 – 760.0 μm (mean 2328.4 μm) in length, 20.0 – 100.0 μm (mean 445.0 μm) in width. Tracheids were measured 150.0 – 1450.0 μm (mean 461.6 μm) in length, 10.0 – 100.0 μm (mean 22.0 μm) in width. Fibers were measured 340.0 – 3200.0 μm (mean 1000.0 μm) in length, 10.0 – 40.0 μm (mean 15.0 μm) in width.

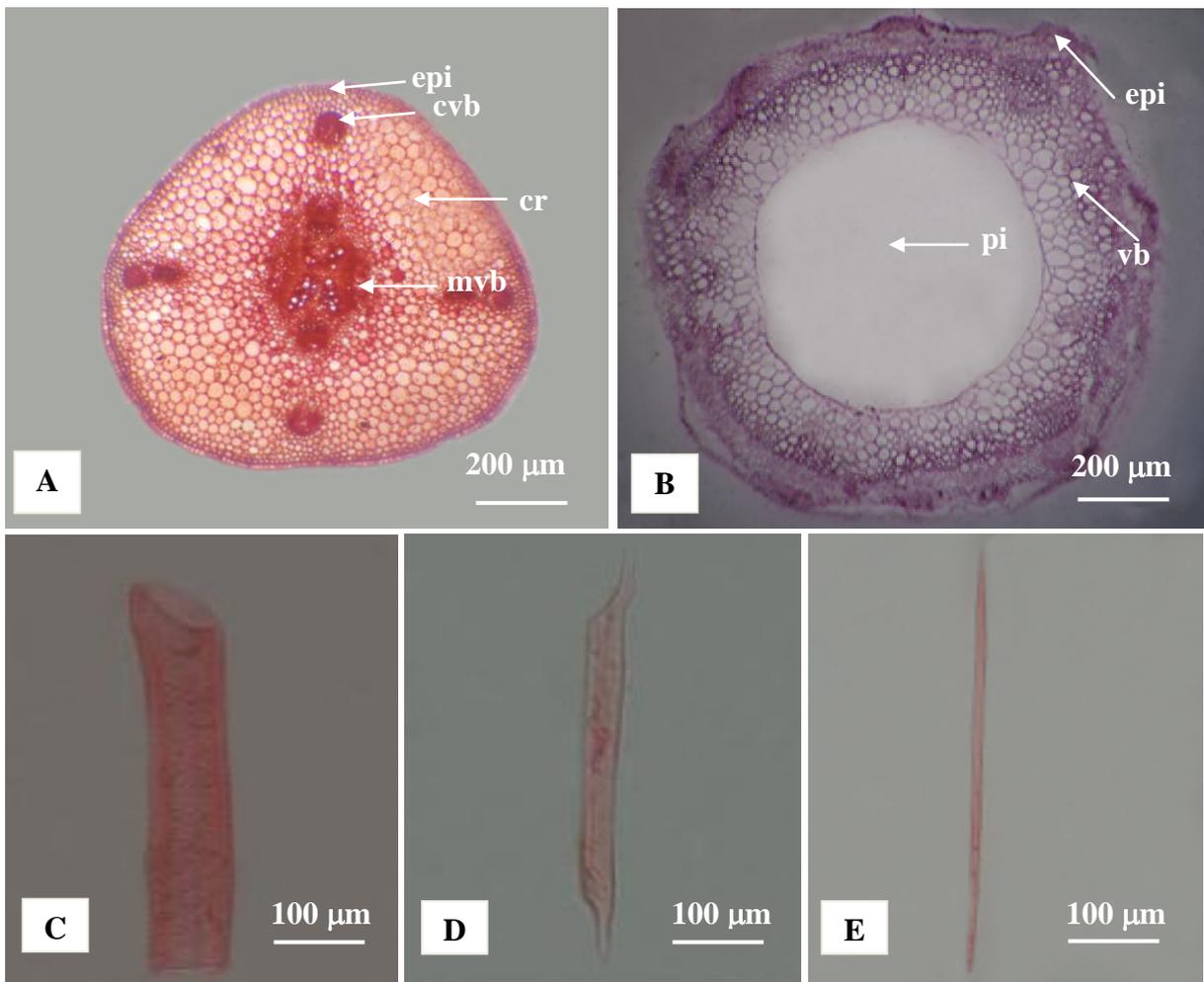


Figure 3 Internal structures of stem of *Pisum sativum* L.

A. T. S of primary body of stem

B. T. S of secondary body of stems showing vascular bundles

C. Vessel element

D. Tracheid

E. Fiber

(epi = epidermal cell, cr = cortex, pi = pith, cvb = cortical vascular bundle, xy = xylem)
m vb = medullar vascular bundle, xy = xylem)

2.3 Internal structure of the roots of *Pisum sativum* L. (Figure 4.4)

Primary body

In transverse section, the root of *Pisum sativum* L. was circular-shaped in outline, 1225.0 – 1675.0 μm in diameter and distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue system: The root epiblema cells 1-layered, parenchymatous, the cells rectangular or irregular in shape, 10.0 – 20.0 μm in diameter.

Ground Tissue System: Composed of cortex, endodermis, pericycle and pith. Cortex homogenous parenchymatous cells, 3- to 7-layered, the layers 300.0 – 600.0 μm thick, the cells polygonal or oval in shape. Endodermis 1-layered, parenchymatous, the cells barrel or oval-shaped. Pericycle 1-layered, continuous, the cells barrel-shaped. Pith absent.

Vascular Tissue system: Vascular bundles embedded in the ground tissues, radial type, vascular cylinder triarch, xylem strands alternating with the phloem group. Xylem elements in exarch condition, with protoxylem towards periphery and metaxylem towards the centre.

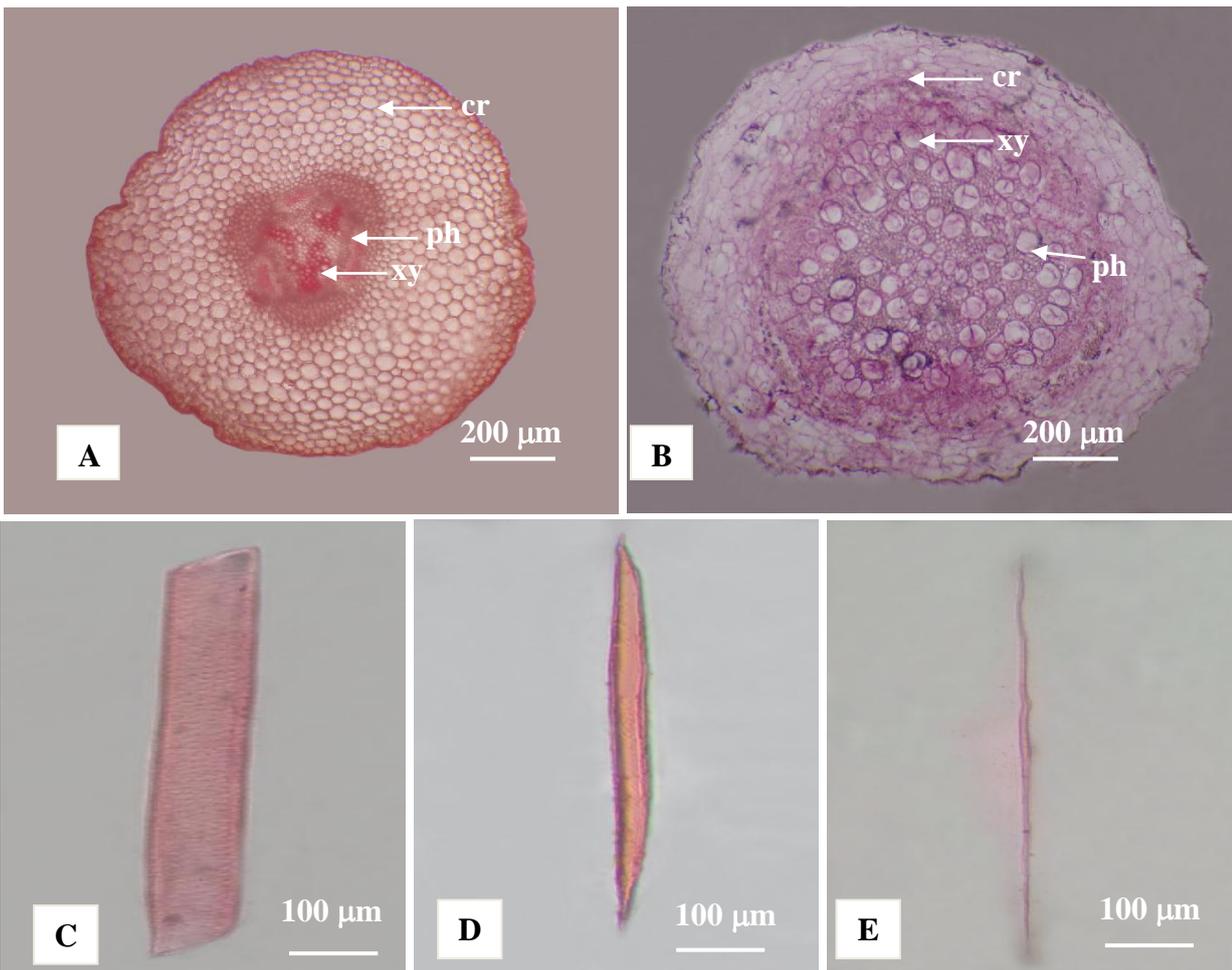


Figure 4 Internal structures of root of *Pisum sativum* L.

A. T. S of primary body of root showing tetrarch vascular bundles

B. T. S of secondary body of root showing polyarch vascular bundles

C. Vessel element

D. Tracheid

E. Fiber

(cr = cortex, r = ray, ph = phloem, pi = pith, xy = xylem)

Secondary Body

In transverse section, the root was circular-shaped in outline, 1000.0 – 1875.0 μm in length, 500.0 - 1750 μm in width.

Dermal Tissue system: The epiblema is crushed and the initiation of periderm is formed.

Ground Tissue System: Composed of cortex, endodermis pericycle and pith. Cortex composed of homogenous parenchyma cell, 8- to 18-layered. Endodermis and pericycle indistinct. Pith absent.

Vascular Tissue System: Vascular bundles occur as a continuous ring, radial type, vascular cylinder polyarch, rays cells occur between the xylem and phloem cells. Phloem distributed at the periphery of the xylem, Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, scalariform, perforation plates simple or scalariform, the cells 60.0 – 340.0 μm (mean 150.8 μm) in length, 20.0 – 90.0 μm (mean 56.4 μm) in width; tracheids elongate, lateral walls straight, end walls bluntly acute or obtuse, thickening pitted, the cells 120.0 – 750.0 μm (mean 516.6 μm) in length, 10.0 – 20.0 μm (mean 10.8 μm) in width; fibers long, lateral walls straight, end walls acute, the cells 480.0 – 2460.0 μm (mean 827.6 μm) in length, 10.0 – 20.0 μm (mean 10.2 μm) in width.

Discussion and Conclusion

The morphological and anatomical characteristics of *Pisum sativum* L. belong to family Fabaceae (subfamily Papilionoideae) were studied in this research. The plant specimens were collected from Shankalay Kyun village, Amarapura Township, Mandalay Region in the year of 2018. The morphological and anatomical characteristics of leaves, stems and roots of *Pisum sativum* L. were studied.

The plants were climbing herbs. The leaves were found to be alternate, unipinnately peripinnate compound with terminal tendrils. These characters were agreed with Backer & Brink (1960), Dassanayake (1991), Yaxley *et al.* (2001), Nian-he (2008) and Trivedi (2014). The shapes of leaves were obovate to elliptic in *Arachis hypogaea* L. and ovate in *Pisum sativum* L.. The stipules were foliaceous and subcordate. These characters were agreed with Backer & Brink (1960), Dassanayake (1991) and Nian-he (2008).

The inflorescences were axillary cyme, 1- to 2-flowered and the flowers were bisexual, zygomorphic, hypogynous and papilionaceous, white; stamens 10 (9+1), diadelphous and free filament filiform. The longitudinal dehiscent pods were observed and the seeds rounded and pale white when mature. These characters were agreed with Dassanayake (1991), Backer & Brink (1960) and Nian-he (2008).

In the transverse sections, the shapes of petioles were quadrangular-shaped and composed of dermal tissue, ground tissue and vascular tissue systems. The ground tissues of petioles were differentiated into the collenchymatous and parenchymatous cells. The cortex was hollow. The types of vascular bundles were collateral type and these characters were agreed with Metcalfe & Chalk (1950) & Ples *et al.* (2013).

The leaves were dorsiventral with reticulate venations. In surface view of lamina, anomocytic type of stomata was found in both surfaces of lamina. In the transverse sections, the shapes of midribs were semicircular in outline. The ground tissues composed of the collenchymatous and parenchymatous cells. The vascular bundles were collateral type, 3 bundles closely appressed to each other. These characters were agreed with Metcalfe & Chalk (1950).

The primary structures of stems were oval-shaped. The vascular bundles were anomalous structure and arranged in two rings. The outer ring cortical vascular bundles consisted of 4 bundles. The inner ring medullary vascular bundles consisted of 4 to 6 bundles. Types of vascular bundles were collateral and these characters were agreed with Compton (1911) and Metcalfe & Chalk (1950).

In secondary body, the transverse sections of stems were circular-shaped. Hollow pith were observed in the ground tissues. The vascular bundles were continuous circular rings; phloem in outer and xylem in inner. These characters were agreed with Metcalfe & Chalk (1950).

The transverse sections of roots were circular-shaped in outline. The vascular bundles were radial type and triarch in the primary body and polyarch in the secondary body. These characters were agreed with Metcalfe & Chalk (1950).

According to the results of present findings, the morphological and anatomical characteristics of *Pisum sativum* L. will be helpful in the identification and classification of family Fabaceae. It is hoped that these findings will be partially fulfilled in the fields of the modern taxonomical and anatomical studies in the near future.

Acknowledgements

We would like to express my gratitude to Dr Nu Nu Yee, Professor and Head, Department of Botany, University of Mandalay, for her permission, encouragement, precious suggestions and kind hearts to do this research work and providing all the departmental facilities. We are thankful to Dr Soe Soe Aung, Professor, Department of Botany, University of Mandalay, for their suggestion and invaluable advice in this research.

References

- Backer, C. A. & R. C. Bakhuizen Van Den Brink. 1960. Flora of Java. Vol. I. Groningen, the Netherlands.
- Compton, R. H. 1911. The anatomy of the mummy pea. New Phytologist, volume 10, Issue 7-8.
- Dassanayake, M. D. 1991. A revised handbook to the Flora of Ceylon. Vol.I. University of Peradeniya, Department of Agriculture, Peradeniya, Sri Lanka.
- Hooker, J. D. 1885. The flora of British India Vol. III, L. Reeve & Co. Ltd. London.
- Jeffery, E. B. 1917. The anatomy of woody plants. 1st ed. University of Chicago.
- Johansen, D. A. 1940. Plant microtechnique. McGraw-Hill Book Company, Inc. New York and London.
- Kyi Kyi Win. 2008. Investigation on chromosomal constitution and principal compounds of *Pisum sativum* L. grown in North Western Myanmar. PhD. Dissertation. Department of Botany, University of Mandalay.
- Levetin, E. & K. McMahon. 2012. Plant & society. 6^{ed}. McGrawhill Companies. New York.
- Metcalfe, C. R. & L. Chalk. 1950. Anatomy of the dicotyledons: leaves, stem and wood in relation to taxonomy with notes on economic uses. Vol. I. Oxford University Press, Amen House, London.
- Morris, B. 2003. Legumes. Encyclopedia of food and Culture. Solomon H. Katz. Vol. 3. New York.
- Nian-he. 2008. Flora of Hong Kong. Vol.II. Agriculture, Fisheries and Conservation Department, Government of the Hong Kong Special Administrative Region.
- Pavek, P. L. S. 2012. Plant guide for pea, *Pisum sativum* L. USDA (United State Department of Agriculture)-NRCS (Natural Resources Conservation Service), Pullman, Washington.
- Ples, D. J. R, D. Purganan & A. Qureshi. 2013. A morpho-anatomical study of the vegetative organs of *Arachis hypogaea* L. M.Sc. Thesis. Ateneo de Manila University, Philippines 1108, 263351828.
- Thin Thin Aye. 2014. Taxonomy and pollen morphology of Fabaceae. Ph.D. Dissertation. Department of Botany, University of Mandalay.
- Trivedi, R. 2014. Morpho-anatomical characterization of groundnut genotypes showing differential reaction to late leaf spot pathogen. An Open Access Journal. ICRISAT. Vol.12.
- Yaxley, J. L., W. Jablonski & J. B. Reid. 2001. Leaf and flower development in pea, *Pisum sativum* L., mutants cochlea and unifoliata. Annals of Botany. 88: 225-234.