

Title	Morphological and Anatomical Studies on <i>Allium sativum</i> L.cv. Yatsauk hmwar phyu
All Authors	Thet Thet Zin
Publication Type	Local publication
Publisher (Journal name, issue no., page no etc.)	Universities Research Journal, Vol.9, No.2
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Keywords	<i>Allium sativum</i> L., Morphology, Anatomy
Citation	
Issue Date	2017

Morphological and Anatomical Studies on *Allium sativum* L.cv. Yatsauk hmwar phyu

Thet Thet Zin¹

Abstract

In this paper, the morphological and anatomical characters of *Allium sativum* L.cv. Yatsauk hmwar phyu was collected from Southern Shan State. It was found that the morphological characters of plant were bolting type and radial distribution of compound bulb. The stomata was anomocytic type. The vascular bundles of leaves, cloves, stems were collateral and the roots are concentric.

Introduction

Alliaceae was composed of 31 genera, cosmopolitan and 700 species, mostly in the northern temperate zone, many cultivate. In some species were have bulbils appear in the inflorescence among the flowers, and form a means of vegetative propagation. *A. sativum* L. enclosed by a sheathing scale and consisting of a thickened leaf base. Mostly cultivated in the upland intermediate region (Dassanayake 2000). Kress *et al.* (2003) stated that family Alliaceae consists of 2 genera and 10 species which are found in Myanmar. According to literature cited, Myanmar garlic or *A. sativum* L. was derived from sub tropical group variety due to having small bulbs (Fritsch & Friesen 2002 as cited in Brewster 2008).

Innvists (2005) described that there are about 300 variety of garlic cultivated worldwide, particularly in hot, dry places. Today garlic is one of the twenty most important vegetables in the world, in an annual production of about three million metric tons. Major growing areas are USA, China, Egypt, Korea, Russia and India as cited in Median & Garcia (2007).

Kothari (1979) stated that the sheath is more conspicuous in the vascular bundles of the storage leaf, have more phloem elements than tracheary elements. Some small bundles consist entirely of phloem elements. Pandey & Chadha (2000) mentioned that the scales of *A. sativum* L. of family Liliaceae, is often made up of a layer of sclereids.

Htwe Htwe Tin Maung (1984) mentioned that mesophyll are differentiated into palisade and spongy layers of *Allium sativum* L. The genus *Allium* consists of epidermal cells of both surfaces similar in shape,

¹ Dr, Demonstrator, Department of Botany, Kyaukse University

size and arrangement, cell parenchymatous, rectangular or polygonal, radially arranged, elongated lengthwise, compact, anticlinal walls straight, laticiferous cells few. Chloroplast abundant, calcium oxalate crystals tetragonal and prismatic.

Mann (1952) had been stated that the stem is round except in early stages of growth. The central cylinder of the stem is a complex network of vascular bundles. The stem is surrounded by a thick cortex. The root traces connect to the outer surface of the vascular cylinder, which except for the openings through which the leaf traces pass, presents an almost continuous layer of vascular tissue. The root traces do not penetrate, as bundles, into any part of the stem vascular network. Cells on the outer surface of the layer of dividing cells develop into the stem endodermis, which becomes continuous with all the root end dermal layers. Kothari (1979) stated that the vascular cylinder in the root is tetrarch with a centrally located metaxylem vessel. Pith is absent.

The present study focused on the morphological and anatomical characters of *A. sativum* L.cv. Yatsauk hmwar phyu, with the following aims and objectives which were to investigate the diverse morphological characters and to describe the differences or similarities of their anatomical structure of *Allium sativum* L.

Materials and Methods

Allium sativum L. were collected from Mandalay Region, from 2013 to 2015. In regard with the morphological characters, specimen were collected at the flowering period to record with the photograph, and then make the herbarium sheath according to (Simpson 2006). For the taxonomical characters the specimens were identified with the help of literature such as Hooker (1879), Backer & Brink (1986), Hill (1933), Dassanayake (2000) and Kaul *et al.* (2006). For anatomical studies were made according to Johansen (1940) method. Specimen were macerated by using Jeffery's (1917) method.

Results

Morphological Studies

***Allium sativum* L. cv. Yatsauk hmwar phyu (Figure 1. A-E)**

Annual, semi-erect 32.0 - 42.0 cm in height, propagate mostly by cloves and rarely by bulb and rarely by bulbils. Bulbs oblate, base flat or rounded, distribution of cloves is radial, 2.8 - 3.6 cm in length 3.1 - 3.5 cm

in breadth; compose of 11 - 23 sessile lateral bulb (cloves), protective bulb create leaves papery of herbaceous smooth and white, the clove 1.0 - 2.4 cm in length and 0.6 - 1.7 cm in breadth; per bulb 2 - 5 sheath, difficult to peel; internodal zone disciform 0.2 - 0.4 cm in length and 1.5 - 2.0 cm in breadth. Leaf 4 - 8, blades linear, non fistulous, 30.8 - 31.5 cm length and 0.2 - 0.5 cm in breadth, the tips acute, the margins entire, grayish-green, longitudinally folded, with a keel on the lower surface, cross section in v shape. Umbels ovoids 1.0 - 1.5 cm in length and 0.4 - 0.6 cm in breadth, the bulbils small, ovoid, 10 - 23 generally sessile, 0.5 - 0.9 cm in length and 0.4 - 0.6 cm in breadth; scape terete, solid, 30.8 - 31.5 cm in length and 0.2 - 0.5 cm in breadth, spathes long, braked, 8.2 - 10.5 cm in length and 5.5 - 6.5 cm in breadth, fragmenting into 1 - 2 pieces, persistent. Fruit not seen. Root fibrous, slender, 4.9 - 9.3 cm in length and 0.1 - 0.2 cm in breadth. The flowering period from February to March.

Anatomical Studies

***Allium sativum* L. cv. Yatsauk hmwar phyu**

Internal structure of leaf (Figure 2. A - G)

In transverse section, the leaf studied were 384.0 - 422.4 μm thick (Figure 2. A), isobilateral with parallel venation. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Composed of two types of cells, namely epidermal cells and guard cells of the stomata without subsidiary. In surface view, upper epidermal cells of both surfaces similar in shape, parenchymatous, polygonal, the cell walls thin, 30 - 580 μm in length, 10 - 25 μm in breadth. Stomata present on both surfaces, abundant, anomocytic type, oval shape, 15 - 40 μm in length, 5 - 15 μm in breadth; guard cells reniform, 25 - 45 μm in length, 5 - 15 μm in breadth. In transverse section, both upper and lower epidermis 1 - layered, the cells barrel shaped, upper epidermal cells 14.4 - 43.2 μm in length, 19.2 - 48.0 μm in breadth, walls straight, outer and inner walls slightly convex, lower epidermal cells 14.4 - 28.8 μm in diameter, walls straight, outer and inner walls slightly convex; cuticle thin on both surfaces, 4.8 μm thick.

Ground Tissue System : Mesophyll differentiated into outer palisade and inner spongy; parenchyma lie beneath the upper and lower epidermis, 1 - layered, cells vertically elongated, upper palisade 28.0 - 57.6 μm in length, the cells compact 14.4 - 33.6 μm in breadth, the cell walls thin, straight, lower palisade 24.0 - 52.8 μm in length, the cells compact, 9.6 - 28.8 μm in breadth, the cell walls thin, straight; laticifers present on both surfaces, 14.4

- 28.8 μm in length and 14.4 - 24.0 μm in breadth; spongy parenchyma 6 to 8 - layered, the cells rounded or oval shaped, 14.4 - 52.8 μm in length, layers 4.8 - 9.6 μm in breadth, intercellular space present. Prismatic calcium oxalate crystals present.

Vascular Tissue System : Vascular bundle embedded in the ground tissue, closed collateral type, oval shaped, 28.8 - 126.6 μm in length, 28.8 - 72.0 μm in breadth; bundle cap parenchymatous, 1 - layered, cells polygonal, 28.8 - 57.6 μm in length, 28.8 - 52.8 μm in breadth, cell walls thick; phloem 1 to 8 - layered, the layers 9.6 - 28.7 μm thick, the cell rectangular, 4.8 - 38.4 μm in length, 4.8 - 28.8 μm in breadth, phloem composed of sieve tube, companion cells, phloem fibers and phloem parenchyma; xylem 1 to 4 - layered, the layers 14.4 - 33.6 μm thick, the cells polygonal, 14.4 - 48.0 μm in length, 14.4 - 33.6 μm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma. Vessel elements thickwalled, lateral walls straight, end walls oblique or transverse, thickenings spiral, perforation plates simple, cells 350 - 425 μm (mean 377.2 μm) in length, 150 - 195 μm (mean 165.8 μm) in breadth; fibers long, lumen narrow, lateral walls straight, end walls acute, cells 340 - 1000 μm (mean 507.0 μm) in length, 10 - 20 μm (mean 15.8 μm) in breadth.

Internal structure of clove (Figure 3. A - G)

In transverse section, the cloves studies were 8 - 10 mm in length and 3 - 6 mm in breadth (Figure 3. B). Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System : Composed of two types of cells, namely epidermal cells and guard cells of the stomata without subsidiary. In surface view, upper epidermal cells and lower epidermal cells similar in shape, parenchymatous cell, rectangular, anticlinal wall straight, the cell 35 - 125 μm in length and 20 - 35 μm in breadth. Stomata present, anomocytic type, oval shaped; guard cells reniform, 25 - 35 μm in length and 10 - 15 μm in breadth. In transverse section, both outer and inner surfaces epidermis 1 - layered, the cells barrel shape, outer epidermal cell 14.4 - 33.6 μm in length and 19.2 - 28.8 μm in breadth, anticlinal walls slightly convex; outer and inner walls slightly convex; inner epidermal cell 9.6 - 24.0 μm in length and 14.4 - 24.0 μm in breadth, outer and inner walls slightly convex; cuticle thin on both surfaces, 4.8 μm thick. Rod shape calcium oxalate crystals present.

Ground Tissue System : The ground tissue 7 to 17 - layered, the layers 312 - 432 μm thick, parenchymatous cells, the cell 24.0 - 134.4 μm in length and 9.6 - 14.4 μm in breadth.

Vascular Tissue System : Vascular bundle embedded in the ground tissue, closed collateral type, oval shaped, 48 - 192 μm in length and 24.0 - 81.6 μm in breadth; bundle cap parenchymatous, 1 - layered, the cell polygonal, 24.0 - 57.6 μm in length and 19.2 - 52.8 μm in breadth; phloem 3 to 5 - layered, the layers 3.6 - 110.4 μm thick, the cells 9.6 - 72.0 μm in length, 9.6 - 57.6 μm in breadth, phloem composed of sieve tube, companion cells, phloem fibers and phloem parenchyma; xylem 1 to 5 - layered, the layers 28.8 - 55.0 μm in thick, the cells 14.4 - 91.2 μm in length and 14.4 - 38.4 μm in breadth, xylem composed of vessel elements, tracheids, xylem fibers and xylem parenchyma. Vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickenings spiral, perforation plates simple, the cell 160 - 225 μm (mean 187.0 μm) in length and 135 - 140 μm (mean 135.4 μm) in breadth; fibers long, lumen narrow, lateral walls straight, end walls acute, the cell 500 - 875 μm (mean 677.6 μm) in length, 10 - 20 μm (mean 12.8 μm) in breadth.

Internal structure of stem (Figure 4. A - F)

In transverse section, the stem studied were 1.0 - 5.1 mm in diameter (Figure 4. A). Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System : In transverse section, epidermis 1 - layered, parenchymatous, the cells barrel shaped, 15.6 - 20.4 μm in tangential diameter, 15.6 - 56.4 μm in radial diameter, the lateral walls straight, both outer and inner walls convex.

Ground Tissue System : The outer cortical tissue 7 to 12 - layered, the layers 120 - 372 μm thick, the cell 14.4 - 30.0 μm in tangential diameter and 14.4 - 48.0 μm in radial diameter; the inner ground tissue 18.0 - 32.4 μm in tangential diameter and 12 - 54 μm in radial diameter. Endodermis 1 - layered, the cell 12.0 - 38.4 μm in tangential diameter and 8.4 - 24.0 μm in radial diameter. Pericycle 1 - layered, the cell 10.8 - 30 μm in tangential diameter and 7.2 - 12.0 μm in radial diameter.

Vascular Tissue System : Vascular bundle arranged in circular ring, collateral type, the bundles 86.4 - 96.0 μm in tangential diameter and 18.0 - 22.8 μm in radial diameter; number of phloem cells 4 - 5, phloem cell 14.4 - 20.2 μm in thick, the cells 15.6 - 19.2 μm in tangential diameter and 14.4 - 18.0 μm in radial diameter, phloem composed of sieve tubes, companion

cell, phloem fibers and phloem parenchyma; number of xylem cell 4 - 5, xylem cell 20.0 - 38.2 μm in thick, the cells 14.4 - 20.2 μm in length and 9.6 - 19.2 μm in breadth, xylem composed of vessel elements, tracheids, xylem fibers and xylem parenchyma, vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickenings spiral, perforation plates simple, vessel 100 - 125 μm (mean 108.4 μm) in length and 20 - 50 μm (mean 34.2 μm) in breadth; fiber 250 - 580 μm (mean 251.4 μm) in length and 20 - 30 μm (mean 25.8 μm) in breadth; macrosclereid 50 - 85 μm in length and 25 - 40 μm in breadth.

Internal structure of root (Figure 5. A - E)

In transverse section, the roots studied were 1.0 - 1.5 mm in diameter (Figure 5. A). Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System : The root epiblema parenchymatous cells, 1 - layered, the cells 12 - 30 μm in tangential diameter and 6 - 18 μm in radial diameter, irregularly rectangular or rounded or barrel in shape.

Ground Tissue System : Composed of exodermis, cortex, endodermis and pericycle. Exodermis 1 - layered, the cells 24 - 60 μm in tangential diameters and 24.0 - 44.4 μm in radial diameter. Cortex 6 to 10 - layered, the cells 12 - 48 μm in tangential diameter, 12.0 - 44.4 μm in radial diameter. Endodermis 1 - layered, the cells 18 - 36 μm in tangential diameter and 8.4 - 24.0 μm in radial diameter. Pericycle 1 - layered, the cells 12.0 - 27.6 μm in tangential diameter and 6.0 - 20.4 μm in radial diameter.

Vascular Tissue System : Vascular bundle arranged as hexarch, radial type; number of xylem strands 4 - 6, number of phloem strands 4 - 6, phloem strands 13.2 - 24.0 μm in tangential diameter and 15 - 18 μm in radial diameter; phloem composed of sieve tubes, companion cell, phloem fibers and phloem parenchyma; xylem strands 15.6 - 42.0 μm in tangential diameter and 18 - 60 μm in radial diameter; xylem composed of vessel elements, tracheids, xylem fibers and xylem parenchyma, vessel elements thick walled, lateral walls straight, end walls oblique or transverse, thickenings spiral, perforation plates simple, vessel elements 250 - 1050 μm (mean 408.2 μm) in length and 25 - 90 μm (mean 49.6 μm) in breadth; the central or axils vessels 33.6 - 78.0 μm in tangential diameter and 39.6 - 84.0 μm in radial diameter; fiber 350 - 1280 μm (mean 651.1 μm) in length and 20 - 30 μm (mean 25.8 μm) in breadth.

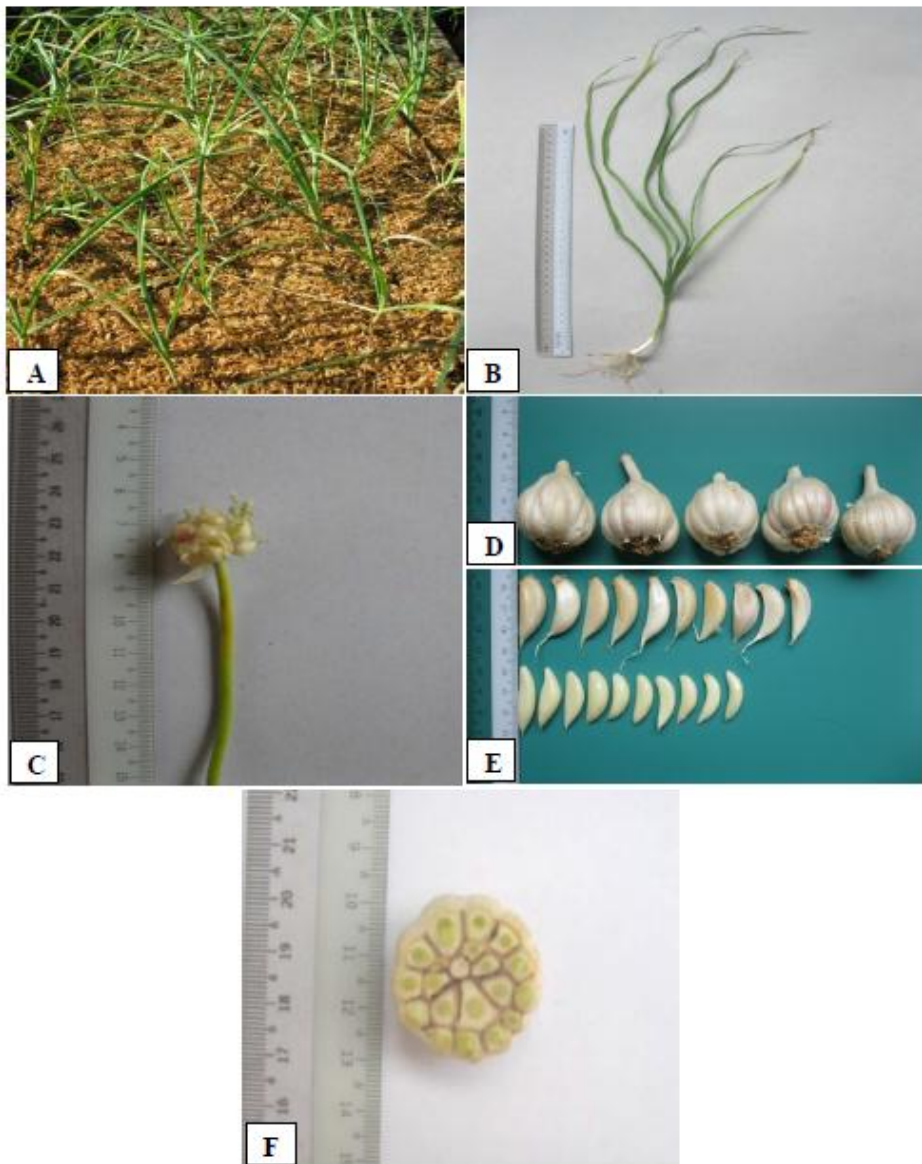


Figure 1. *Allium sativum* L. cv. Yatsauk hmwar phyu

A. Plot cultivation D. Bulbs

B. Habit E. Clove

C. Scape

F. T.S of bulb showing radial position

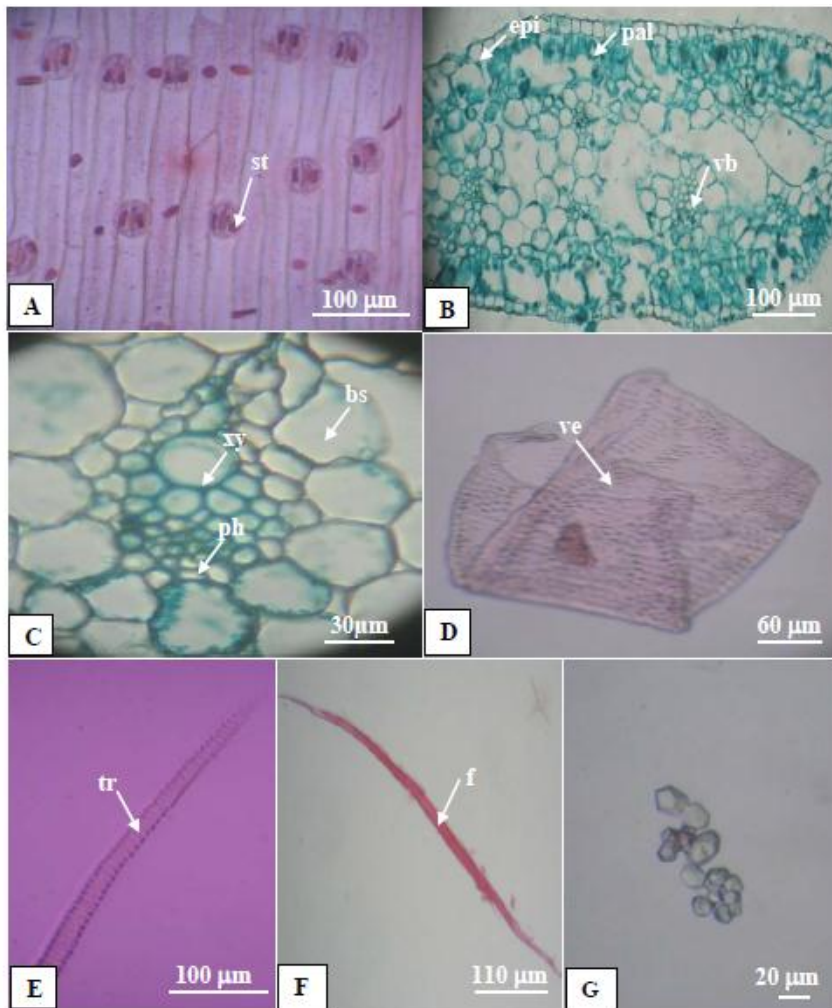


Figure 2. Internal structure and macerated elements of leaf of *Allium sativum* L. cv. Yatsauk hmwar phyu

A. Surface view of leaf showing epidermal cells and stomata
 B. T.S of leaf showing mesophyll tissue and vascular bundle
 C. Close up view of vascular bundle
 D. Vessel element E. Tracheary element
 F. Fiber G. Prismatic calcium oxalate crystals
 (st-stomata, epi-epidermis, pal-palisade parenchyma cell, vb-vascular bundle, bs-bundle sheath, xy-xylem, ph-phloem, ve-vessel element, tr-tracheary element, f-fiber)

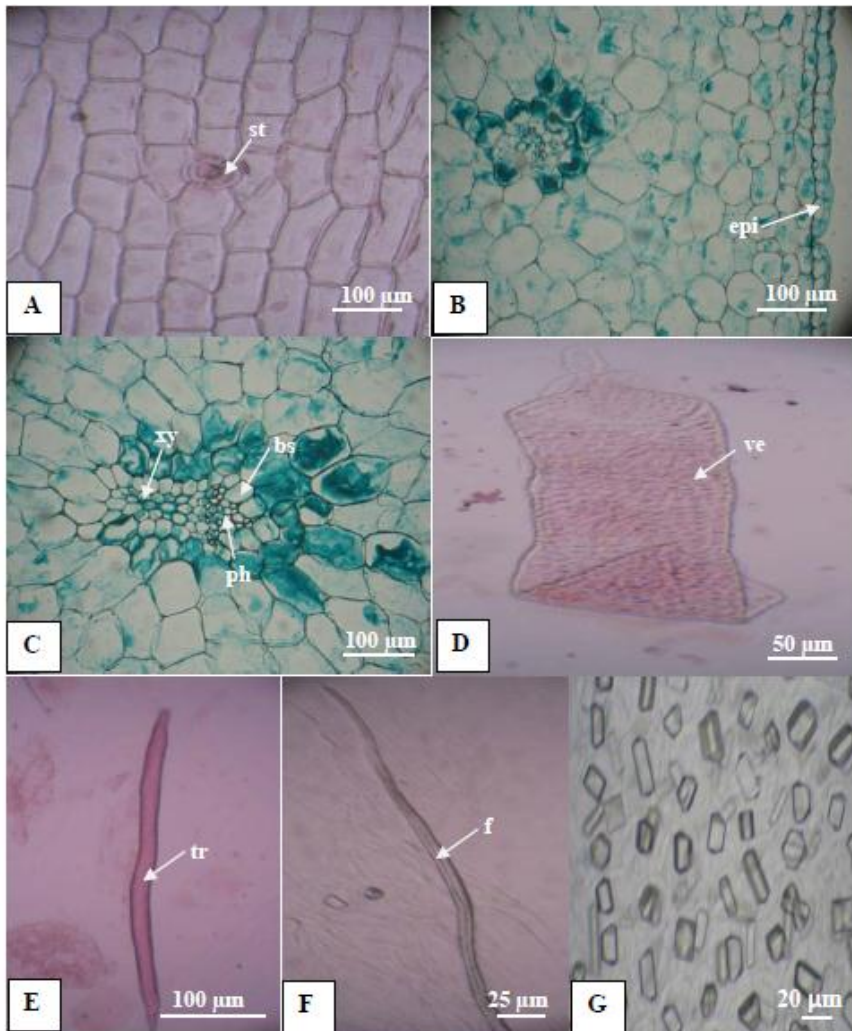


Figure 3. Internal structure and macerated elements of clove of *Allium sativum* L. cv. Yatsauk hmwar phyu
 A. Surface view of clove showing epidermal cells and stomata
 B. T.S of clove showing outer epidermis and ground tissue
 C. A close up view of vascular bundle
 D. Vessel element E. Tracheary element
 F. Fiber G. Rod shape calcium oxalate crystals
 (st-stomata, epi-epidermis, bs-bundle sheath, xy-xylem, ph-phloem, ve-vessel element, tr-tracheary element, f-fiber)

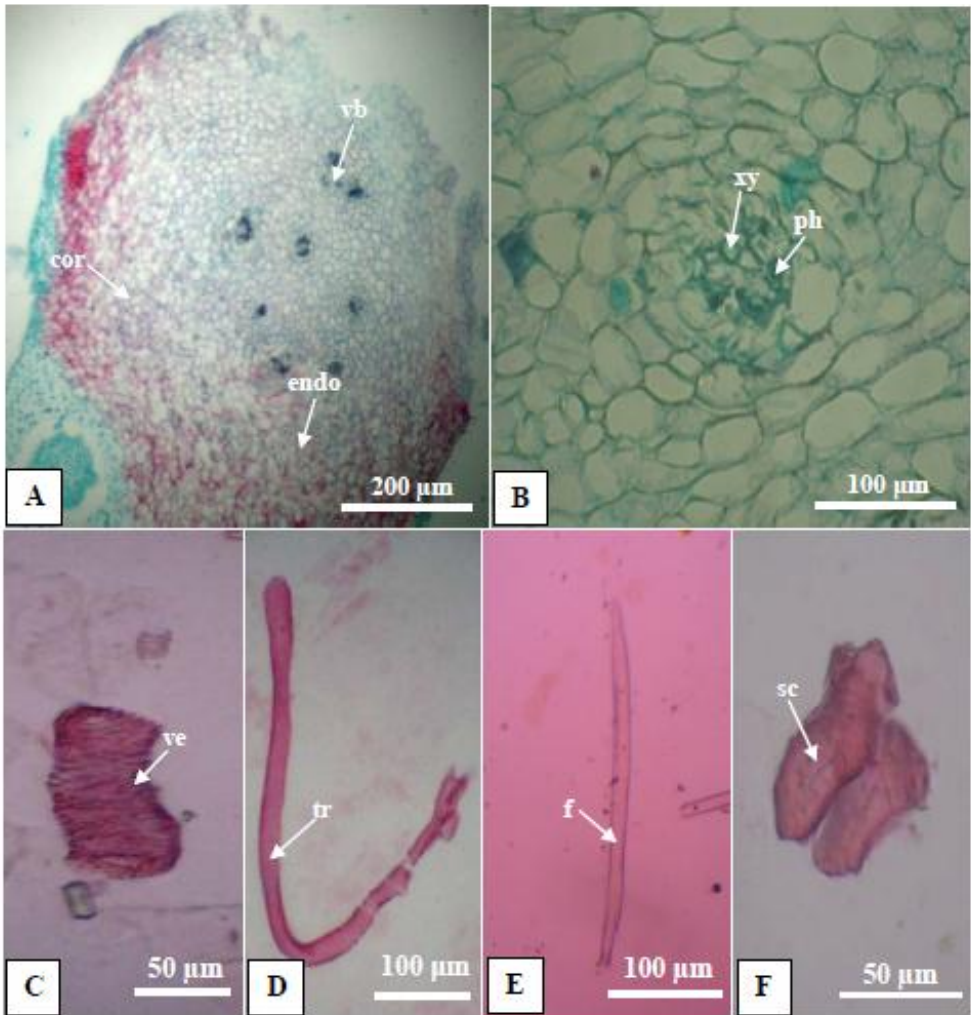


Figure 4. Internal structure and macerated elements of stem of

Allium sativum L. cv. Yatsauk hmwar phyu

A. T.S of stem showing cortex and vascular bundle

B. Close up view of vascular bundle

C. Vessel element

D. Tracheary element

E. Fiber

F. Macrosclereid

(cor-cortex, endo-endodermis, vb-vascular bundle, xy-xylem, ph-phloem, ve-vessel element, tr-tracheary element, f-fiber, sc-sclereid)

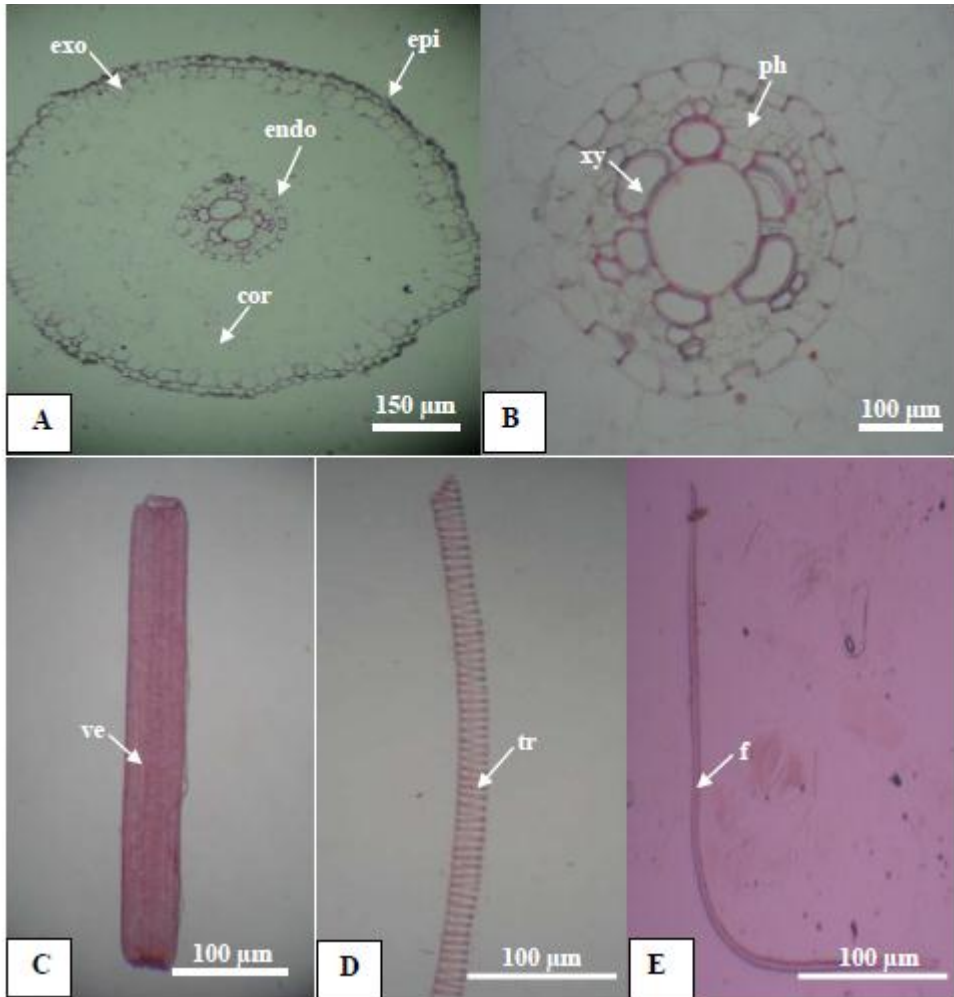


Figure 5. Internal structure and macerated elements of root of *Allium sativum* L. cv. Yatsauk hmwar phyu
 A. T.S of root showing epiblema, cortex and vascular bundle
 B. Close up view of vascular bundle showing hexarch vascular bundle
 C. Vessel element
 D. Tracheary element
 E. Fiber
 (epi-epiblema, exo-exodermis, cor-cortex, endo-endodermis, xy-xylem, ph-phloem, ve-vessel element, tr-tracheary element, f-fiber)

Discussion and Conclusion

In the present study, morphological and anatomical characters of vegetative and reproductive parts *Allium sativum* L.cv. Yatsauk hmwar phyu were presented. The plant is herb, bulb circular, broadly ovoid, single or compound bulb. Leaves green, linear, tips acute, margins entire, longitudinally folded and keeled on the lower surface.

Bolting type or produced scape was found in cv. Yatsauk hmwar phyu. This character was agreed with hardneck varieties (Meyers 2006). In the case the number of bulbils pre plant was 10 - 23, radial distribution of compound bulb and white color of bulb and cloves was found in Yatsauk hmwar phyu.

Dassanayake (2000), bulb 8 - 10 mm broad, cylendric, covered with decayed and fibrous outer scales; roots many, fibrous. Leaves 25 - 70 cm × 8 - 10 mm, narrowly linear, channelled above, keeled beneath, rather fleshy, glaucous green. Inflorescence globose, laxly many flowered. Hooker 1881, had been described *A. sativum* L. leaves flat, scape slender, spathes long-beaded, heads bearing bulbils and flowers, sepals lanceolate acuminate, inner filaments 2 - toothed.

According to Meyers 2006, garlic can be classified into two main categories such as hardneck and softneck in terms of varieties. Cultivars can be classified more wider range than varteities and it depends on the characters of bolting and non-bolting, radial, non radial, shape of bulbs, colour, odor and tastes (Meyers 2006 and Rosen *et al.* 2008).

According to literature cited, Myanmar garlic or *A.sativum* L. was derived from sub tropical group variety due to having small bulbs (Fritsch & Friesen 2002 as cited in Brewster 2008). Recent research findings suggested that Myanmar cultivar of *A. sativum* L. derived from two different origins that of bolting and non-bolting groups.

Garlic cultivar was commercially cultivated in Upper Myanmar. The anatomical studies of the vegetative parts of leaves, cloves, stems and roots were studied, described and compared. The anatomical characteristics were studied by using plant microtechnique the according to method of Johanson' (1940).

Leaves were found to be isobilateral leaf and the transverse section of showed the three tissue systems of dermal, ground and vascular tissue system. In transverse section, dermal tissue system composed of one layer of epidermal cells on both surfaces. Stomata were present abundant on both size. Outer and inner wall are slightly convex. In the ground tissue system

of leaves was made up of parenchymatous cells of different sizes, and laticifer were found in ground tissue. In ground tissue, distinct bundle cap was found in this cultivars. Vascular bundle of leaves were usually oval or rounded shape in transverse section. Vascular bundle was found to be collateral type. The leaves were isobilateral type, this character was agreed with Metcalfe & Chalk (1960) and Pandey & Chadha (2000).

The leaves was composed of differentiated into palisade and spongy parenchyma, these characters were agreed with Htwe Htwe Tin Maung 1984. Palisades were 1 - layered on both surfaces under the epidermis and right angles of the leaf epidermis, these characters were in agreement with those stated by Pandey & Chadha 2000. Laticifers were present on both surfaces of under palisade layer. The owned laticifer present in leaf mesophyll. They were located between the second and third layers of parenchyma, this character was coincide with Mann 1952, Esau 1965; Cronquist 1981 and Htwe Htwe Tin Maung 1984. The spongy cells were variable shape and were loosely arranged with abundant intercellular spaces. The intercellular spaces which maintain continuity with stomatal chamber facilitate the gaseous exchange. Spongy mesophyll were 3 to 9 - layered, cells were rounded or oval in shape.

In transverse sections of cloves were measurement of cloves length and breadth, layers numbers of cortex, upper and lower epidermis, stomata type, types of vascular bundles, xylem and phloem layers and cuticle thick were compared. The dermal and ground tissue was composed of parenchymatous tissue. The bundle cap are most conspicuous than leaves. Vascular bundle was observed in collateral type, xylem 1 - 5 layered, phloem 3 - 5 layered. Cuticle thin was presence on both outer and inner surface. Scattered vascular bundles are embedded in ground tissues this character was agreed with Gupta *et al.* (2005).

In transverse sections, stems are oval or rounded in shape. The cortex was 372 μm in thick, 5 - 13 layers and collateral type of vascular bundle. The macrosclereid was present.

Mann (1952) had been stated that the stem is round except in early stages of growth. The central cylinder of the stem is a complex network of vascular bundles. The stem is surrounded by a thick cortex. Cronquist (1981) described that the genus *Allium* with articulated laticifers, starch present in the vegetative organs of some genera, vessels with scalariform or simple perforations, usually confined to the roots, but sometimes also present in the stems, vascular bundles of the stem closed, scattered on several irregular cycle.

In transverse section of roots were circular in outline. The parenchymatous epiblema cells are one layered and rectangular to quadrangular in shape. Single layer of exodermis was found in under epiblema. There are 6 to 10 layers of cortex in ground tissue system. Pith was not found in the center. The vascular strands are hexarch, concentric vascular bundle and endodermis layer is conspicuous. The root vessel elements were found to be simple perforation plates in cv. Yatsauk hmwar phyu.

Mann (1952), the root traces connect to the outer surface of the vascular cylinder, which except for the openings through which the leaf traces pass, presents an almost continuous layer of vascular tissue. The root traces do not penetrate, as bundles, into any part of the stem vascular network. Cells on the outer surface of the layer of dividing cells develop into the stem endodermis, which becomes continuous with all the root end dermal layers. The leaves and cloves were found in prismatic and rhomboid shaped crystals which were agreed with WHO 1995 and Gupta *et al.* 2005. They stated that cells contain many rhomboidal crystals of calcium oxalate.

Therefore the results provided the fulfill knowledge gap of morphological and anatomical characters of cultivar *Allium sativum* L.

Acknowledgements

I would like to acknowledge with deepest gratitude to Dr Nu Nu Yee, Professor and Head of Botany Department, University of Mandalay for her kind permission, encouragement and for providing all the department facilities during the study period. My special thank are also due to Dr Soe Myint Aye, Professor, Department of Botany, University of Mandalay for his kind permission and encouragement. I do wish to express my thank to supervisor Dr Kalaya Lu, Associate Professor, Department of Botany, University of Mandalay, for her kind supervision good advice and constant encouragement in this research work.

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