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Anatomical Characteristics of *Comos sulphureus* Cav. from Family Asteraceae

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Abstract

In this research, morphological and anatomical structures of leaves, stems, and roots of *Comos sulphureus* Cav. of tribe Heliantheae belonging to the family Asteraceae were studied, photomicrographed and described. This species is annual erect herb, compound leaves and flowers are bisexual head. Anatomical characters of *Cosmos sulphureus* Cav. are dorsiventral type of leaves, anomocytic type of stomata, and collateral type of vascular bundles were found. The shapes of midrib are found to be oval-shaped, the petioles were oval or heart-shaped, and the stem was tetragonal or polygonal in shape.
Key words – Asteraceae, dorsiventral, anomocytic, collateral

Introduction

In people's lives plants were important and were essential to balance the nature. Plants served the most important part in the cycle of nature. Without plants, there could be no life on earth. Plants were the only organisms and they can make their own food. People and animals were incapable to make their own food and depend directly or indirectly on plants for their supply of food. There were many plants that were edible and that were used by rural people but the main emphasis was on commercial important plants (Wyk 2005).

Comos sulphureus Cav. is also known as crest lemon, sunset, cosmic yellow and cosmic orange. It is well known as cosmos in English name (McLeod 2007). *Comos sulphureus* Cav. is known as dye plant and is cultivated for this purpose. It is also found in tropics and subtropics of worldwide and then generally it is known for antibiotic and homeostatic properties (Grierson 1980).

Plant anatomy has also been established for strong traditional research in India. External morphological characters can prove taxonomic value and they can be readily observed with naked eye or simple hand lens. Finally, it should be remembered that there are numerous problems in forensic science that can be solved by histological method (Metcalfe and Chalk 1979).

The histological investigation can give the contribution to the corpus of taxonomic knowledge whenever it is intelligently used. Histological data concerning the vegetative organs of plants serve as additional criteria that can be used to solve taxonomic problems (Metcalfe and Chalk 1983). Then, the investigation such as cytology, palynology, embryology, and chemotaxonomy can support as other criteria to be taken into account in modern taxonomy. The taxonomic and phylogenetic value of histological characters is still severely limited by the lack of enough factual data to enable reliable conclusions to be drawn (Metcalfe and Chalk 1983). To overcome such limitation, the work of histological investigation with a taxonomic aim is required in many taxa throughout the dicotyledons. Vegetative anatomy is undoubtedly important in the relation to taxonomy.

Anatomical data had also solved several phylogenetic problems, and several herbarium specimens had also been identified by Metcalfe and Chalk using their vegetative anatomy (Sharma 1993). It is undoubted that such supporting subjects are important to taxonomy. In this research work, morphological characteristics of *Comos sulphureus* Cav. from Mandalay Region and the anatomical characteristics of their leaves, stems and roots are studied and described. Photographs of their vegetative and reproductive parts are given and photomicrographs of internal structure of leaves, stems and roots are also presented.

The main objective of this present study is to understand the morphological and anatomical characteristics of *Comos sulphureus* Cav, and to consider the importance of vegetative anatomy in relation to taxonomy for preparation of the flora of Myanmar.

Materials and Methods

The species of *Comos sulphureus* Cav. was collected from Pyin Oo Lwin Township of Mandalay region. Field notes were made of precise location and of habitat type. They were recorded and photographed in the field trip. After the collection, the vegetative and floral parts of fresh specimens were studied, measured and identified by using literature

(Hooker 1881; Heywood 1978; Grierson 1980; Cronquist 1981) based on the earlier record in Department of Botany, University of Mandalay. Some of collected specimens were dried and pressed to make herbarium sheet.

The collected specimens were preserved in 50% solution of ethyl alcohol for further morphological and anatomical study.

For anatomical studies, the fresh and preserved specimens were examined by preparing free-hand section. These plant parts were cut by using a new razor blade to obtain thin sections (about 0.5 – 1 mm in thickness) for microscopic study. These plant sections were cleared in chloral hydrate solution on a glass slide and stained with saffranin solution and temporarily mounted in dilute glycerin solution.

Maceration of leaves, stems and roots were made by boiling the materials in equal volume of 50% acetic acid and 50% hydrogen peroxide according to the method of Jaffery (1917).The plant section and macerated components of plant parts were fixed in standard F.A.A solution (90ml of 50% or 70% of ethyl alcohol, 5ml of glacial acetic acid and 5ml of formalin employed by Johansen (1940). The plant section and macerated components of plant parts were measured by the microscope with an ocular micrometer which was then calibrated against at a stage micrometer. After calibrating, an ocular micrometer was used to determine the size of a cell in terms of length, breadth and diameter by the formula. Photomicrographic plates of the free-hand sections were also prepared by the use of a microscope with digital camera and presented in this research.

Morphological studies

1. *Cosmos sulphureus* Cav., Chlor. And. 56. t. 79. 1791. (Figure 1)
   Cosmea sulphurea Willd., Sp. Pl. 3:2250.1803.
   Adenolepis calva Sch., Fl. 2:79. 1900.
   Bidens calva Clarke, Compd. Ind. 141. 1876.
   Bidens sulphurea Sch. Bip, in Seem., Bot. Voy. Herald. 301. 1856.
   Myanmar name : Shwe dinga pan
   English name : Mexico
   Flowering period : August to March

Annual erect herbs, 0.5-1 m tall; stems 5-angular, hairy or glabrous. Leaves bi or tripinnate compound or pinnatisects, opposite, petiolate; petioles 1-4 cm long; leaf segments linear-lanceolate or elliptic, 2.0-6.5 cm by 1.5-6.0 cm, attenuate at the base, entire along the margin, acute or acuminate at apex, glabrous on both surfaces. Capitula solitary on terminal or axillary

peduncles, heterogamous, radiate, 2.5-4.0 cm across at anthesis, pedunculate; peduncles 3.0-14.0 cm long, glabrous; involucres campanulate, 5.0-10.0 mm in diameter, biseriate, outer phyllaries 8, linear-lanceolate, 6.0-10.0 mm by 1.5-2.0 mm, foliaceous, inner ones 7, 7.0-11.0 mm by 2.0-3.0 mm, oblong-lanceolate, scarious; receptacle flat, paleaceous; paleae linear, 7.0-12.0 mm by 1.0-2.0 mm, scarious. Ray florets 8 per capitulum, neuter ligulate; ligules oblong-ovate, 1.0-2.3 cm by 0.5-1.4 cm, 3- to 5- toothed, golden yellow or orange or yellow; basal tube slender, 1.0 mm long. Disc florets numerous, tubular, bisexual, fertile, yellow or orange; corolla tube infundibuliform, 5.0-8.0 mm long; lobes 5, lanceolate; basal tube 1.0-2.0 mm long; stamens 5, slightly exserted; anthers obtuse at the base, apical appendage acute; ovary 3.0-9.0 mm long, oblong, ribbed, pappose; style exserted; stylar arms linear with complanate tip. Achenes oblong, 1.5-2.0 cm long, rostrate, greyish-black, 0.5-1.0 cm long. Pappus retrosely barbed awns, 3 or 4, unequal, 2.0-5.0 mm long, divergent, persistent.

Figure 1 Morphological characters of *Cosmos sulphureus* Cav.
A Habitat **B** Habit

Anatomical Studies
Internal Structure of the leaf of *Cosmos sulphureus* Cav.

Petiole

In transverse section, the petiole of *C. sulphureus* Cav. (Figure 2 A) studied is oval or heart-shaped in outline, semicircular at the abaxial side and straight at the adaxial side, 1428.0-2856.0 μm in tangential diameter,

1309.0-1785.0 μm in radial diameter. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Composed of epidermal cells and trichomes.

In transverse section both upper and lower epidermis one-layered, the cells barrel or oval-shaped or rounded; upper epidermal cells 24.0-52.8 μm in length, 28.0-36.0 μm in breadth, anticlinal walls straight, outer and inner walls convex; lower epidermal cells 26.4-50.4 μm in length, 26.4-48.0 μm in breadth, anticlinal walls straight, outer and inner walls convex; cuticle present on both surfaces, 2.4-9.6 μm in thick; trichomes 480.0-672.0.0 μm in length, 19.0-38.4 μm in breadth, multicellular and uniseriate.

Ground Tissue System: Composed of outer collenchymatous cells and inner parenchymatous cells as main mass of ground tissue. Outer collenchymatous layers below the adaxial and above abaxial epidermis; those at adaxial side, 2 to 3- layered, the layers 14.4-24.0 μm in thick, the cells 16.8-31.2 μm in length, 12.0-26.4 μm in breadth, polygonal; those at abaxial side, 2 to 3- layered, the layers 16.8-24.0 μm in thick, the cells 12.0-36.0 μm in length, 7.2-26.4 μm in breadth, polygonal; inner parenchymatous layers below adaxial and above the abaxial collenchymatous layer; those at adaxial side 8 to 10- layered, the layers 67.2 105.6 μm in thick, the cells 38.4-124.8 μm in length, 48.0-105.6 μm in breadth, rounded or oval-shaped; those at abaxial side 4 to 7- layered, the layers 153.6-240.0 μm in thick, the cells 124.8-355.2 μm in length, 115.2-288.0 μm in breadth, rounded or oval-shaped; intercellular space present on both side.

Vascular Tissue System: Occurred in 7 to 9 groups of farcically arranged in crescent shaped of bicollateral type and close vascular bundle, the middle bundle large, peripheral bundles small, the bundle 67.2-432.0 μm in tangential diameter, 67.2-384.0 μm in radial diameter, oval-shaped; phloem lying on both side of xylem, phloem 5 to 10- layered, the layers 12.0-24.0 μm in thick, the cells 9.6-31.2 μm in length, 7.2-26.4 μm in breadth, phloem composed of sieve-tubes elements, companion cells, phloem parenchyma and phloem fibers; xylem arranged in 2 to 9 radial rows, 2 to 7-celled in each row, the cells 7.2-48.0 μm in length, 7.2-43.2 μm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma; vessel elements 105.6-528.0 μm in length, 9.6-38.4 μm in

breadth, lateral walls straight or wavy end walls transverse, tapering obliquely acute, tailed either at one or both ends, thickening spiral reticulate and pitted, the pits simple and alternate, perforation plates simple; tracheids 79.2-280.8 μm in length, 12.0-24.0 μm in breadth, lateral wall straight or wavy, end walls tapering or obliquely acute, thickening spiral and pitted, the pits simple; fibers 132.0-1248.0 μm in length, 9.6-48.0 μm in breadth, thick-walled, lumen narrow, lateral walls straight, end walls acuminate.

Lamina

In transverse section, the lamina of *C. sulphureus* Cav. (Figure 2 B) studied is 153.6 - 211.2 μm in thickness. Typically dorsiventral, venation reticulate. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tussue System : Composed of epidermal cells, guards cells of the stomata and trichomes.

In surface view epidermal cells parenehymatous, compactly arranged anticlinal walls of upper epidermal cells thick and slightly wavy, cells 20.4-81.25 μm in length, 15.0-56.25 μm in breadth; irregularly arranged cells walls of lower epidermal cells thin and more wavier, cells 30.0-87.5 μm in length, 17.5-43.75 μm in breadth; stomata anomocytic type, more abundant on abaxial surface; stomata at adaxial surface 11.25-31.25 μm in length, 2.5-5.0 μm in breadth, guard cells 12.5-35.0 μm in length 5.0-7.5 μm breadth; stomata at abaxial surface 12.5-37.5 μm in length, 2.5-6.25 μm in breadth, guard cells 15.0-43.75 μm in length, 6.25-8.75 μm in breadth. In transverse section, both upper and lower epidermis one-layered, the upper cells 14.4-72.0 μm in length, 9.6-43.2 μm in breadth, compact, oval or barrel-shaped, the anticlinal wall straight, outer and inner walls convex; cuticle on both sides, 2.4 μm in thick; the lower epidermal cells 19.2-38.4 μm in length, 12.0-33.6 μm in breadth, outer and inner walls convex.

Ground Tissue System : Mesophyll differentiated into palisade and spongy parenchyma; palisade parenchyma present at adaxial side, one-layered, cells vertically elongated or funnel-shaped, 36.0-74.4 μm in length, 12.0-36.0 μm in breadth, chloroplast abundant; spongy parenchyma present at abaxial side, 3- to 5-layered, the layers 12.0-19.2 μm in thick, cells

rounded arm-shaped or irregular in shape, 14.4-40.8 μm in length, 9.6-36.0 μm in breath, intercellular space large, chloroplast abundant.

Vascular Tissue System : The vascular bundles embedded in ground tissue, collateral type, oval-shaped, 67.2-230.4 μm in horizontal diameter, 38.4-220.8 μm in vertical diameter; bundle sheath one-layered, parenchymatous, cells barrel or oval-shaped, 16.8-60.0 μm in length, 16.8-40.8 μm in breadth, cell walls thin; xylem on the adaxial side and phloem on the abaxial; side; phloem 2-to 5-layered, the layers 4.8-9.6 μm in thick, cells 2.4-21.6 μm in length, 2.4-24.0 μm in breadth, phloem composed of, sieve-tubes, companion cells, phloem parenchyma and phloem fibers; xylem cells 1 to 4 radial rows, 1 to 5- celled in each row, the cells 4.8-45.6 μm in length, 2.4-24.0 μm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma; bundle sheath extension parenchymatous present; vessel elements 91.2- 624.0 μm in length, 7.2-16.8 μm in breadth, thick-walled, lateral walls straight or slightly wavy, end walls oblique or transverse or tapering or obliquely acute, tailed either at one or both ends, thickening spiral, reticulate and pitted, the pits simples and alternate, perforation plates simple; tracheids 98.4-624.0 μm in length, 7.2-12.0 μm in breadth, thick-walled, lateral walls straight, end walls oblique or acute, annular ring, mostly thickening spiral; fibers 384.0-624.0 μm in length, 19.2-28.8 μm in breadth, thick-walled, lumen narrow, lateral walls straight, end walls acuminate.

Midrib

In transverse section, the midrib of *C. sulphureus* Cav. (Figure 2 C) studied is oval-shaped in outline, semicircular at the abxial side and prominent ridges at adaxial side, 476.0-761.6 μm in tangential diameter, 595.0-952.0 μm in radial diameter. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Composed of epidermal cells and trichomes.

In transverse section; both upper and lower epidermis one-layered the cells rounded or barrel- shaped; upper epidermal cells 9.6-74.4 in thick, trichomes 192.0-432.0 μm in breath, 12.0-38.4 μm in breadth, anticlinal walls straight, outer and inner walls convex, lower epidermal cells 9.6-40.8 μm in length 7.2-33.6 μm in breadth; cuticle 23.8-432.0 μm in thick,

trichomes 192.0-432.0 μm in length, 24.0-38.4 μm in breadth, multicellular and uniseriate.

Ground Tissue System: Consist of outer collenchymatous and inner parenchymatous cells as main mass of ground tissue. Outer collenchyma below the adaxial and above abaxial epidermis; those at adaxial side 2 to 3-layered, the layers 190.4-261.8 μm in thick, the cells 119.0-404.6 μm in length, 9.6-33.6 μm in breadth, polygonal; those at abaxial side one-layered, the cells 14.4-48.0 μm in length, 16.8-43.2 μm in breadth, polygonal; inner parenchymatous layers below adaxial and above the abaxial collenchymatous layers; those at adaxial side 2 to 3- layered, the layers 19.2-48.0 μm in thick, the cells 96.-60.0 μm in length, 7.2-31.2 μm in breadth, rounded or oval or polygonal, intercellular space small; those at abaxial side 2 to 3- layered, the layers 16.8-31.2 μm in thick, the cells 14.4-84.0 μm in length, 16.8-72.0 μm in breadth, rounded or oval shaped, intercellular space small, resin ducts present.

Vascular Tissue System: Occurred in 3 groups of farcically in crescent shape of bicollateral type and close vascular bundle, the middle large, peripheral bundles small, the bundles 36.0-180.0 μm in tangential diameter, 48.0-240.0 μm in radial diameter, oval or rounded in shape; phloem 3 to 7-layered, the layers 12.0-24.0 μm in thick, the cells 9.6-26.4 μm in length, 12.0-24.0 μm in breadth, irregular in shape, phloem composed of sieve-tubes elements, companion cells, phloem parenchyma and phloem fibers; xylem cells 2 to 5 radial rows, 2 to 7- celled in each row, the cells 7.2-33.6 μm in length, 9.6-26.4 μm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma; vessel elements 105.6-336.0 μm in length, 9.6-28.8 μm in breadth, lateral walls straight, or wavy, end walls oblique or transverse or tapering, tailed either absent or present at one end, thickening spiral and pitted, the pits simple and alternate, perforation plates simple; tracheids 280.0-2208.0 μm in length, 14.4-38.4 μm in breadth, thick-walled, lateral walls straight, end walls tapering or obliquely acute, annular ring, mostly thickening spiral; fibers 480.0-1248.0 μm in length, 19.2-38.4 μm in breadth thick-walled, lumen wide lateral walls straight, end walls acuminate.

Internal Structure of the Stem of *Cosmos sulphureus* Cav.

In transverse section, the stem of *C. sulphureus* Cav. (Figure 2 D) studied is polygonal or tetragonal shape in outline, 1666.0-3094.0 μm in tangential diameter, 1785.0-2975.0 μm in radial diameter. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: Composed of epidermal cells and trichomes.

In transverse section, epidermis one-layered, parenchymatous, the cells rounded or barrel-shaped, 12.0-40.8 μm in length, 9.6-24.0 μm in breadth, the lateral walls straight, both outer and inner walls convex, trichomes 86.4 - 153.6 μm in length, 28.8 - 38.4 μm in breadth, elongated multicellular and uniseriate.

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, cells 2 to 3- layered, the layers 14.4-19.2 μm in thick, cells rectangular in shape, 7.2-24.0 μm in length, 4.8-21.6 μm in breadth, thickening angular. Parenchymatous cells occur in continuous cylinder, 3 to 4-layered, the layers 24.0-36.0 μm in thick, the cells rounded or oval-shaped, 16.8-60.0 μm in length, 14.4-40.8 μm in breadth, intercellular space present. Endodermis one-layered, the cells 24.0-60.0 μm in length, 12.0-36.0 μm in breadth, compact and continuous parenchymatous, barrel-shaped, thin-walled. Pericyclic sclerenchymatous forming discontinuous crescent-shaped, the cells 3 to 10- layered, the layers 12.0-21.6 μm in thick, irregularly polygonal in shape, 96.0-28.8 μm in length, 7.2-26.4 μm in breadth. Pith cellular large, 952.0-2023.0 μm in diameter, the cells 28.8-153.6 μm in length, 19.2-124.8 μm in breadth, parenchymatous, thin-walled, oval or rounded or polygonal in shape, intercellular space present.

Vascular Tissue System: Vascular bundle arranged in a discontinuous circular ring collateral type, about 19-21 bundles, the bundles 12.0-120.0 μm in tangential diameter, 24.0-84.0 μm in radial diameter; phloem outer and xylem inner, phloem 3 to 5-layered, the layers 9.6-14.4 μm in thick, the cells 7.2-24.0 μm in length, 4.8-19.2 μm in breadth, small oval or irregular in shape, phloem composed of sieve-tube elements, companion cells, phloem parenchyma and phloem fibers; vascular cambium developed between xylem and phloem, 1 to 2- layered, the layers 9.6-14.4 μm in

thick, cells rectangular, radially flattened, thin-walled, 12.0-26.4 μm in length, 4.8-16.8 μm in breadth; xylem 57.6-288.0 μm in thick, the cells 24.0-50.4 μm in length, 9.6-48.0 μm in breadth, rounded or polygonal in shape, xylem composed of vessel elements, tracheids, fiber-tracheids, fibers and xylem parenchyma; vessel elements 124.8-451.2 μm in breadth, thick -walled, the lateral walls straight or curved, end walls oblique or transverse or tapering or obliquely acute, tailed either at one or both ends, thickening spiral, reticulate and pitted, the pits simple and alternate, perforation plates simple; tracheids 201.6-1536.0 μm in length 19.2-96.0 μm in breadth, lateral walls straight or wavy, end walls tapering or obliquely acute, thickening spiral and pitted, the pits simple; fiber-tracheids 259.2-787.2 μm in length, 9.6-124.8 μm in breadth, thick walled, lumen broad, non-septate, lateral walls straight or wavy, end walls tapering or obliquely acute, the pits slit-like, scattered; fibers 384.0-1267.2 μm in length, 9.6-28.8 μm in breadth, long, thick-walled, lumen narrow, lateral walls straight, end walls acuminate.

Internal Structure of the Root of *Cosmos sulphureus* Cav.

In transverse section, the root of *C. sulphureus* Cav. (Figure 2 E) studied is circular in outline, 1190.0-2856.0 μm in diameter. Distinguishable into dermal, ground and vascular tissue systems.

Dermal Tissue System: The root epiblima parenchymatous cells, one-layered, the cells 19.2-52.8 μm in length, 14.4-48.0 μm in breadth, irregularly rectangular or rounded or barrel in shape.

Ground Tissue System: Composed of cortex, endodermis, pericycle and pith. Cortex 7- to 10- layered, the layers 16.8-33.6 μm in thick, parenchymatous, oval or round or irregular in shape, cells 19.2-84.0 μm in length , 14.4-57.6 μm in breadth. Endodermis inconspicuous. Pericyclic sclerenchymatous, discontinuous, 4 groups, 2 to 3-layered, the layers 9.6-19.2 μm in thick, the cells 7.2-50.4 μm in the breadth, polygonal or irregular-shaped. Pith widely plus-shaped, large, parenchymatous, 238.0-1190.0 μm in diameter, the cells 38.4-134.4 μm in length, 28.8-105.6 μm in breadth, oval or rounded in shape.

Vascular Tissue System: Vascular bundles occurs as continuous ring, collateral type, vascular cylinder polyarch; phloem distributed at the periphery of the xylem, 7 to 10 -layered, the layers 14.4-24.0 μm in thick,

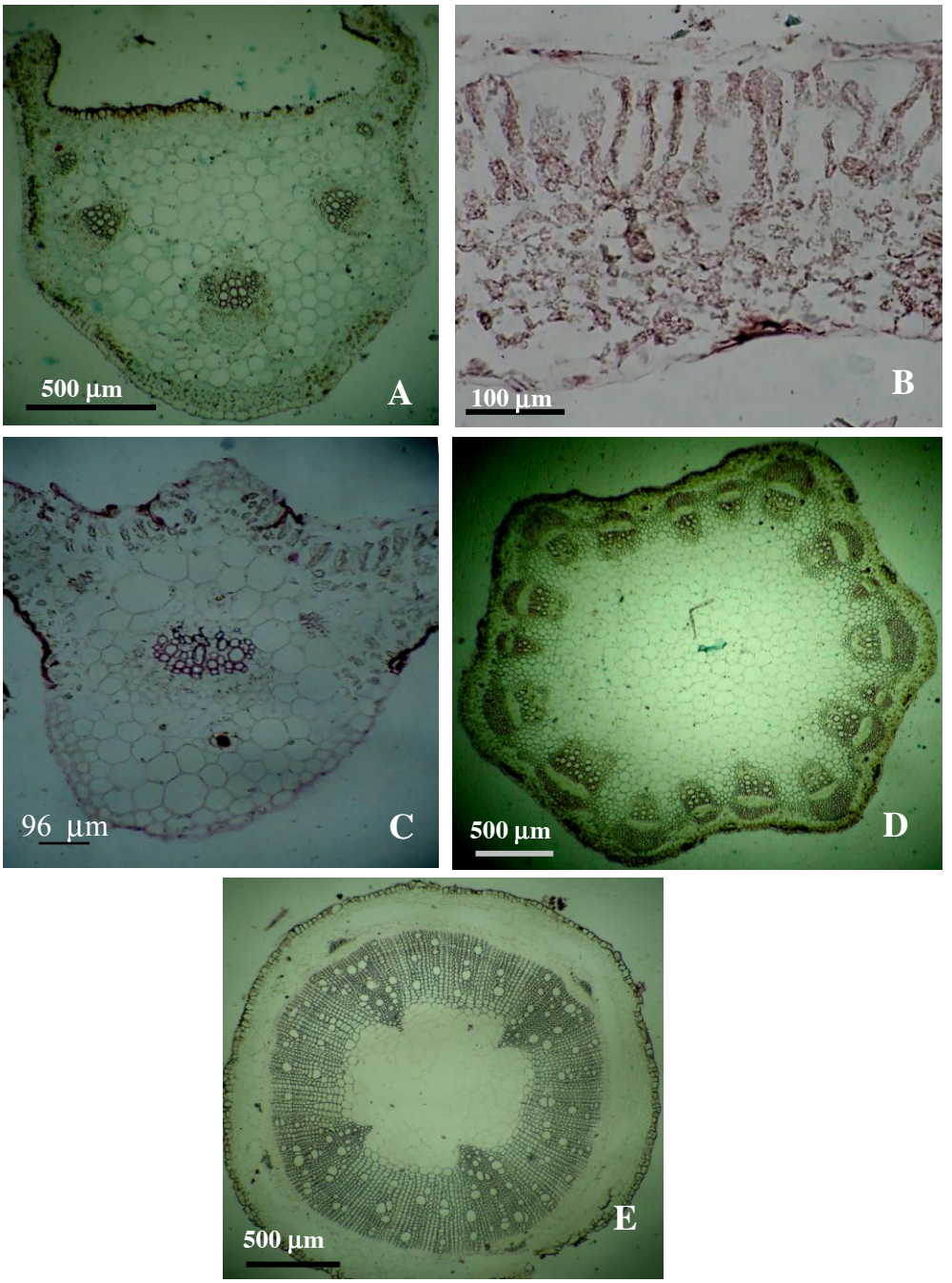

Figure 2 Internal structure of *Cosmos sulphureus* Cav.

A. T.S of a petiole **B.** T.S of lamina **C.** T.S of a midrib
D. T.S of a stem **E.** T.S of a root

the cells 9.6-48.0 μm in length, 9.6-24.0 μm in breadth; phloem composed of sieve-tube elements, companion cells, phloem parenchyma and phloem fiber; xylem arranged as a continuous cylinder and in the form of radiate group, 166.6-952.0 μm in thick, cells polygonal or rounded, 14.4-115.2 μm in breadth, xylem composed of vessel elements, tracheides, fiber-tracheids, fiber and xylem parenchyma; vessel elements 105.6-297.6 μm in length, 14.4-76.8 μm in breadth, lateral walls straight or curved, end walls oblique or transverse or tapering or obliquely acute, tailed either at one end or both ends, thickening pitted, the pits simple and alternate, perforation plates simple; tracheids 60.0-240.0 μm in length, 12.0-38.4 μm in breadth, thick walled, lateral walls straight or wavy, end walls tapering or blunt or obliquely acute, mostly pitted, the pits simple; fiber-tracheids 96.0-528.0 μm in length, 14.4-48.0 μm in breadth, thick-walled, lumen broad, the lateral walls straight or wavy, end walls tapering or obliquely acute, the pits slit-like, scattered. parenchyma and phloem fibers; xylem composed of vessel elements, tracheids, fibers and xylem parenchyma.

Discussion and Conclusion

Morphological and anatomical characteristics of species *Cosmos sulphureus* Cav. growing in Mandalay Region belonging to the tribe Heliantheae of the family Asteraceae had been investigated in this research. This species was cultivated.

In this study, corollas of the ray florets of *Cosmos sulphureus* Cav. was white in colour, the stem was hairy, leaf segments linear-lanceolate or elliptic; outer involucral bracts linear-lanceolate, inner oblong-lanceolate; ray florets 8 in number, golden yellow or orange or yellow; achenes oblong. Small (1933) stated that *Cosmos sulphureus* Cav. stem was often pubescent; leaf segments elliptic or lanceolate; involucral bracts linear; ray flowers 8 – 10; ligules orange-yellow, achenes fusiform.

Several distinctive anatomical features of laminae, midribs, petioles, stems and roots of *Cosmos sulphureus* Cav. had been observed.

The leaves of all studied species were dorsiventral type but palisade mesophyll cells were found on both sides of lamina of *Helianthus annuus* L.. This finding agreed with that of Kadereit and Jeffrey (2007), Bhattacharyya (1998) and Pandey and Chadha (1993) who stated that in dorsiventral on dicotyledonous leaves and concentric leaves with reticulate venation, mesophyll tissue were found differentiated into two types of cells.

In transverse section, thickness of lamina of all studied species was varied. The epidermis of laminae was composed of three types of cells. They were epidermal cells, guard cells of stomata and trichomes. The epidermal cells were one-layered and parenchymatous. In the lamina surface of all studied species upper epidermal cell walls were thicker than walls of lower epidermal cells.

In surface view of lamina of *Cosmos sulphureus* Cav., stomata were anomocytic type. Moreover walls of epidermal parenchyma cells on lower surface were wavier than those of upper surface. This type of stomata agreed with that of Takhtajan (2009), Kadereit and Jeffrey (2007), Pandey and Chadha (1993), Cronquist (1981), Metcalfe and Chalk (1979) and Metcalfe and Chalk (1950) they mentioned that not only anomocytic type of stomata but also anisocytic type was found in Asteraceae family. Twenty eight types of stomata were described by Metcalfe and Chalk (1979). In dicotyledons four main types of stomata were reported by Esau (1965).

Although anomocytic type of stomata was found on both surface of lamina of *Cosmos sulphureus* Cav., stomata were more on lower surface of lamina. This finding agrees with that of Pandey and Chadha (1993) who reported that stomata distributed equally on both surface of lamina. Stomata were present on lower surface than those on upper surface.

According to the present study, ground tissue of lamina of this species was differentiated into palisade parenchyma and spongy parenchyma. Palisade parenchyma was only one layer in ground tissue of *Cosmos sulphureus* Cav.. In vascular bundles of species, bundle sheaths were distinct and were one-layered with thin-walled parenchyma cell. Vascular bundles of *Cosmos sulphureus* Cav. were collateral type and round or oval in shape. Phloems were present at abaxial side and xylems were present adaxial side. This finding agreed with that of Pandey and Chadha (1993) and Metcalfe and Chalk (1950) but some features of tissue of lamina of *Cosmos sulphureus* Cav. was different with those of Metcalfe and Chalk (1950) who mentioned that mesophyll tissue were very variable and were composed of wholly of palisade cells.

In transverse section, the shapes of midrib are found to be oval-shaped in *Cosmos sulphureus* Cav.. Moreover they were semicircular at abaxial side and prominent ridges at adaxial side in *Cosmos sulpureus* Cav..

In transverse section, the shape of petioles of *Cosmos sulphureus* Cav. were oval or heart-shaped.

According to the present study, the transverse section of stem of *Cosmos sulphureus* Cav. was tetragonal or polygonal in shape.

Metcalfe and Chalk (1950) stated that distribution and abundance of collenchyma and pattern of collenchyma thickening was important in systematic criterion in family as cited in Singh, *et al*. (1994).

In this study, endodermis of stem was the innermost layer of the cortex and is composed of one parenchyma layer. This finding agreed with that of Metcalfe and Chalk (1950) and Esau (1960). But Singh, *et al*. (1994), mentioned that stem endodermis could show much variation in structure of cells and in families like Asteraceae as cited in Sharma (1993).

In the present study, pericycle of stem is composed of sclerenchymatous sheath occurred discontinuously at the outer boundary of phloem groups of vascular bundle and was crescent-shaped. This finding agreed with that of Esau (1960), Foster (1965), and Metcalfe and Chalk (1950), Pandey and Chadha (1993), and Bhattacharyya (1998). In this work, pith of stem is composed of many layers of parenchyma cells occurred at central part of stem. The character of pith agreed with that of Metcalfe and Chalk (1950), Kadereit and Jeffery (2007) Metcalfe and Chalk (1979) and Pandey and Chadha (1993).

Vascular bundles of stems of all studied species were collateral type and were varied in number of bundles. The vascular bundles of *Cosmos sulphureus* Cav. is forming as discontinuous ring This finding agreed with that of Pandey and Chadha (1993), Esau (1960), Takhtajan (2009), Eame and MacDaniels (1947), Metcalfe and Chalk (1950), Cronquist (1987) and Kadereit and Jeffrey (2007) who mentioned that herbaceous stems of Asteraceae family had generally a single ring of collateral bundles. The bundles may be closely spaced or even formed a complete in wood member. The medullar bundles were mostly found in Asteraceae family and cortical bundles may also be found in this family. Secondary growth is usually present in tribe Heliantheae. According to Takhtajan (2009), secondary thickening well developed or was absent in herbaceous species of Asteraceae family. Eames and MacDaniels (1947) mentioned that in dicotyledons, the herbaceous plant possessed cylinder of vascular tissue. Vascular cylinder was found in some species of Asteraceae family. Metcalfe and Chalk (1950) mentioned that in Asteraceae family, stems of herbaceous occurred with a single ring of collateral vascular bundles but bundles appeared closely or even formed as wood cylinder in the shrubby and arboreal members of this Asteraceae family. In stem of young seedings of Asteraceae family, vascular bundles were found as a ring and as continuous cylinder.

Anatomy of stem structure was important in separating higher categories of the plant. Sharma (1993) stated that the character of primary were the most important anatomical feature. This feature had been used in resolving problems of taxonomy and phylogeny.

In transverse section, the roots of the studied species were circular in shape. The primary epidermal cells of roots were disorganized and displaced by the formation of epiblema or protective layers which consists of one layer. In the roots of studied species, endodermis and pericycle developed as a continuous ring of parenchyma cells but endodermis were inconspicuous and pericycle developed as a discontinuous strands of sclerenchyma or perivascular fiber in the root of *Cosmos sulphureus* Cav.. Vascular bundles of roots of species *Cosmos sulphureus* Cav. which occurred as a continuous ring with large pith cellular. This finding agree with that of Esau (1960), Esau (1965), Pandey and Chadha (1993), Foster (1965), Metcalfe and Chalk (1950) and they mentioned that in root epidermis is also called epiblema and is outermost uniseriate layer composed of thin walled parenchyma. Some of the roots of mature plant have a solid core of xylem surrounded by a protective layer of periderm in Asteraceae family. Periderm formed in herbaceous dicotyledons but especially occurred in the oldest part of stem and root.

Cortex of root is composed of parenchyma cell only but if it is persistent, it may develop sclerenchyma or it may become collenchymatous. The presence of conspicuous intercellular space is characteristics of the root cortex.

Endodermis is usually one seriate but in many root of Asteraceae family endodermis cells occurred into two-layered zones. In seed plants the endodermis is considered to be in the root but the stems of a number of angiosperm and of mostly herbaceous plant developed endodermis. The pericycle of relatively young roots has thin-walled parenchyma. The root of gymnosperms consists of a multiseriate pericycle but uniseriate is also present. In the angiosperms the pericycle of root is commonly one seriate but in many monocotyledons and a few dicotyledons pericycle of root is found as several layers. In the roots of higher plant, pericycle occurred uniformly. The pericycle is composed entirely of parenchyma or it may contain sclerenchyma. In most roots, the pericycle is uniseriate and lied in direct with protophloem and protoxylem tissue. If the xylem cannot be differentiated in the center of root, pith consisting of parenchyma or sclerenchyma is present. In many root, the center of vascular cylinder is occupied by a core of parenchyma or sclerenchyma. They are usually

designated as pith. The thick, soft and succulent root of Asteraceae family is distinct with central pith. The pith is surrounded by a radiate xylem which appears stellate and present medullary rays between the arms. Pith is distinct with parenchymatous type. In older root pith is absent.

It was observed that the characters of root of studied species were similar to literature but some characters were slightly different from the literature.

In maceration of all studied species, vessels, tracheids and fibers were present throughout plant part. In addition to these elements, fiber-tracheids were found in stem and root. But fibers were not found in root. Thickening was spiral, reticulate and pitted in vessel. The pits were simple and alternate. Perforation plates were simple and tails were at one or both end or absent. Thickening was annual and mostly spiral in tracheids of laminae, midribs, petioles and stems but pitted tracheid were present only in stems and roots. Lumen were broad and thick-walled were in fiber-tracheid. The pits were scattered and were slit-like.Fibers were thick-walled and were wide to narrow lumen. This finding was similar with that of Foster (1965), Esau (1965), Cronquist (1981), Bhattacharryya (1998), Metcalfe and Chalk (1950), Metcalfe and Chalk (1983), Kadereit and Jeffrey (2007), Takhtajan (2009) and Pandey and Chadha (1993).

The importance and significance of histological characters are variable from one family to another and even histological character of vegetative organs viz. lamina, midrib, petiole, stem, root of the same plant can be different to each other. Therefore, histological data concerning the vegetative organs can be used to solve taxonomic problem. The students today often remain unaware of the value of practical application of systematic anatomy. This is to be regretted at a time when there is so much interest, especially when practical problems are solved among the botanist. It is hoped that principles of systematic anatomy should be used to solve the practical problem within many species.

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