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Leaf venation patterns of selected twenty-seven accessions of *Cucumis* taxa

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ABSTRACT

Twenty-seven accessions from six (6) *Cucumis* L. taxa were observed to determine and elaborate differences when it comes to leaf venation patterns or leaf architecture characters. In this study, matured leaves from *Cucumis* species and subspecies namely: *C. pustulatus* Naudin ex Hook.f., *C. dipsaceus* Ehrenb. ex Spach, *C. ficifolius* A. Rich., *C. melo* ssp. *melo*, *C. africanus* L.f., and *C. myriocarpus* ssp. *myriocarpus*, were collected and subjected to leaf venation analysis. The leaf venation patterns of these *Cucumis* accessions were fully highlighted and illustrated in this study following the research published by Masungsong *et al*. (2023). Results showed that the *Cucumis* accessions exhibited similarities in apex shape (convex), base shape (lobate), base angle (wide obtuse), apex angle (odd lobed obtuse), laminar shape (orbiculate with distinct serrations at the margins), primary vein (actinodromous suprabasal), secondary vein (craspedodromous), quaternary vein (regular polygonal reticulate), and marginal ultimate venation (looped). Dissimilarities of leaf characters were observed in blade class, primary vein size, and secondary vein spacing. These results were congruent to the previously studied Cucumis species. Thus, the use of leaf architecture or leaf venation analysis is very valuable in describing and categorizing taxonomically complicated species like *Cucumis*.

Keywords: dissimilarities, leaf morphology, vein spacing, venation patterns.

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INTRODUCTION

Traditionally, identifying and classifying plant species- within and between- largely depends on reproductive structures. Vegetative traits such as leaf morphology, are often disregarded due to their vulnerability to environmental factors such as light, temperature, soil conditions, humidity, and others (Gratani, 2014). Leaf architecture, basically venation pattern, is one of the genetically stable plant morphological features since it is highly distinctive and remarkably diverse among and within species (Roth-Nebelsick *et al.*, 2001). Therefore, in the absence of these reproductive structures, leaf venation patterns can serve as valuable tools for taxonomic classification and identification (Buot, 2020; Huiet *et al*., 2018). Several researchers have proven the effectiveness of leaf architecture applications in distinguishing and delineating different taxa including the controversial *Hoya* species R. Br. (Salvaña and Buot, 2014; Villareal and Buot, 2015; Jumawan and Buot, 2016; Torrefiel and Buot, 2017; Tan and Buot, 2018; Baltazar and Buot, 2019; Paguntalan and Buot, 2019), *Saxifraga* Tourn. ex L. (Zhang, 2015), *Diplazium* Sw. (Conda *et al*., 2017), *Adiantum* L. (Huiet *et al*., 2018), and *Aquilaria* Lam. and *Gyrinops* (Gilg.) Domke (Zharotul and Ratna, 2019).

Cucumis species, collectively known as cucumbers, encompass a diverse and globally cultivated group of plants that belong to the gourd family, Cucurbitaceae. These significant plant species are valued globally because of their economic and cultural importance. Remarkable leaf architectural studies (Rao and Rao, 2015; Masungsong *et al*. 2019a; Masungsong *et al*., 2019b; Averion-Masungsong and Buot, 2020; Masungsong *et al*., 2022; Masungsong *et al*., 2023) have unraveled the complexities of their leaf morphology and contributed to the better understanding of their taxonomic relationships.

This research provided thorough descriptions and visual illustrations of the leaf architecture of the *Cucumis* accessions featured in the research conducted by Masungsong *et al.* in 2023.

MATERIALS AND METHODS

Collection, pressing, and drying of leaf samples

A total of two hundred forty-three (243) leaf specimens from twenty-seven (27) accessions of six (6) *Cucumis* taxa namely: *C. pustulatus* (27 leaves), *C. dipsaceus* (45 leaves), *C. ficifolius* (36 leaves), *C. melo* ssp. *melo* (45 leaves), *C. africanus* (45 leaves), and *C. myriocarpus* ssp. *myriocarpus* (45 leaves) were gathered, pressed, dried, and subjected to leaf architectural analysis. These species were strategically planted at the Hortanova Farm and Research Center, Eastwest Seed Company Inc. in Lipa City, Batangas, Philippines. Prepared herbarium specimens for each accession were placed at the Plant Biology Division Herbarium (PBDH) of the Institute of Biological Sciences, University of the Philippines, Los Baños.

Leaf architecture investigation

The two hundred forty-three (243) dried leaf samples were examined under a dissecting

microscope. The leaf venation characteristics were determined using leaf architectural descriptors found in Hickey's (1973), LAWG's (1999), and Ellis' *et al*. (2009) published works. To maintain uniform classification for all *Cucumis* species and accessions utilized, an identical set of general and leaf venation features were described. Leaf sketches were also provided to visualize the leaf venation of the studied *Cucumis* accessions. These characters were already enumerated in the study of Masungsong *et al*. (2023).

This study aimed to provide comprehensive descriptions and visual representations of the six (6) *Cucumis* species (*C. pustulatus*, *C. dipsaceus*, *C. ficifolius*, *C. melo* ssp. *melo*, *C. africanus*, and *C. myriocarpus* ssp. *myriocarpus*) to gain a more definite understanding of their leaf venation patterns, as introduced by Masungsong *et al*. (2023).

RESULTS AND DISCUSSION

General leaf characters and venation patterns of the selected *Cucumis* taxa

The examined *Cucumis* species and subspecies namely: *C. pustulatus*, *C. dipsaceus*, *C. ficifolius*, *C. melo* ssp. *melo*, *C. africanus*, and *C. myriocarpus* ssp. *myriocarpus* revealed significant similarities in terms of their leaf morphological features.

These species exhibited comparable traits in their overall leaf architecture, encompassing characteristics like leaf shape, symmetry, apex and base shapes, margin type, tooth apex, and lobation. In general, these *Cucumis* taxa displayed traits such as orbiculate laminar shape, symmetrical lamina, convex apex shape, lobate base shape, serrated leaf margins, spinose tooth apex, and palmate lobation.

Noteworthy dissimilarities in leaf features were observed in their blade characters. Among the six (6) *Cucumis* taxa, only *C. ficifolius* had a microphyll to mesophyll blade classification, while the others displayed mesophyll blades (*C. pustulatus* and *C. melo* ssp. *melo*) or exclusively notophyll blade classification (*C. dipsaceus*, *C. africanus*, and *C. myriocarpus* ssp. *myriocarpus*). Comparable results were observed in the study of Masungsong *et al*. (2019a and b; 2022) where blade class effectively distinguished *C. anguria* from *C. anguria* var. *longaculeatus*. Conversely, two *C. anguria* accessions exhibited similar blade classification, which grouped them alongside *C. anguria* var. *longaculeatus*, indicating a close resemblance between these two mentioned varieties.

All six (6) *Cucumis* taxa used in this study show a peculiar odd-lobed obtuse apex angle. This level of lobation can be determined by examining the apex angle of lobed leaves and the leaf surface area. These features are closely connected to leaf shape which impacts the overall leaf structure of the species. Moreover, measurements of leaf attributes, including the apex angle, play a crucial role in the numerical taxonomic approaches used for species characterization (Nandyal *et al*., 2013).

The overall leaf venation patterns of the examined accessions of *Cucumis* taxa exhibited actinodromous suprabasal primary vein, straight branched primary vein course,

craspedodromous secondary veins, two-pair acute basal secondaries, alternate percurrent tertiary veins, obtuse tertiary vein angle in relation to primary vein category, regular polygonal reticulate quaternary vein, looped marginal ultimate venation, and well-developed areolation. Furthermore, differences were observed in their primary vein size and secondary vein spacing. Four (4) significant categories were formed according to primary vein size: (1) those exhibiting moderate primary vein size (*C. dipsaceus* and *C. africanus*), (2) weak (*C. pustulatus*, *C. melo* ssp. *melo*), (3) weak to stout (*C. myriocarpus* ssp. *myriocarpus*), and (4) weak to moderate (*C. ficifolius*). These categorizations were also found valuable by Salvaña *et al*. (2018) and Mantovani *et al*. (2009) in their conducted leaf architectural study of *Podocarpus* species and *Anthurium* subsections, respectively.

Two (2) valuable categories were established based on the secondary spacing of the examined *Cucumis* taxa: (1) those with increasing toward the base secondary vein spacing (*C. pustulatus* and *C. melo* ssp. *melo*) and (2) those with irregular secondary vein spacing (*C. dipsaceus*, *C. ficifolius*, *C. africanus*, and *C. myriocarpus* ssp. *myriocarpus*). These two categories are also observed in previously studied *Cucumis* species documented by Masungsong *et al*. in 2019 and 2022. The apex angle and secondary vein spacing are closely linked to the presence of lobation, where species with unlobed leaves tend to have a larger surface area compared to palmately lobed species. The presence of lobations in leaves plays a vital role in distinguishing specific vein patterns and offers insights into accurate homologous and/or ancestral lineages (Yang *et al*., 2022).

A dichotomous key utilizing leaf architecture characters was created based on the descriptions of each examined species. The key and accompanying descriptions demonstrate that leaf architecture, particularly venation characters, is a highly useful marker for describing the studied *Cucumis* taxa.

Key to six *Cucumis* L. taxa based on leaf architecture

1. 2° vein craspedodromous with irregular spacing ……..……...…… 2
1. 2° vein craspedodromous with increasing towards the base spacing …….....……..……. 3
2. 1° vein actinodromous suprabasal, with moderate vein size ……....……..…. 4
2. 1° vein actinodromous suprabasal, with weak to moderate or weak to stout vein size..... ..5
3. Symmetrical, orbiculate, mesophyll with 1.00 to 1.25 L:W ratio ……...…...… *C. pustulatus*
3. Symmetrical, orbiculate, mesophyll with 0.88 to 1.11 L:W ratio……..….. *C. melo* ssp. *melo*
4. Palmately lobed, notophyll with 0.97 to 1.16 L:W ratio …….....……. *C. dipsaceus*
4. Palmately lobed, notophyll with 0.97 to 1.60 L:W ratio …….....…….... *C. africanus*
5. Weak to moderate 1° vein size …….....…..……..… *C. ficifolius*
5. Weak to stout 1° vein size …….....……. *C. myriocarpus* ssp. *myriocarpus*

Leaf architectural descriptions and illustrations of selected *Cucumis* taxa

***Cucumis pustulatus* Naudin ex Hook.f. (Figures 1a–c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7537 (PBDH), Masungsong and Alcala 7538 (PBDH), Masungsong and Alcala 7539 (PBDH)

Lamina orbiculate with convex apex, odd lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, mesophyll with 1.00 to 1.25 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and weak primary vein; secondary vein craspedodromous with increasing towards the base vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

Figure 1a

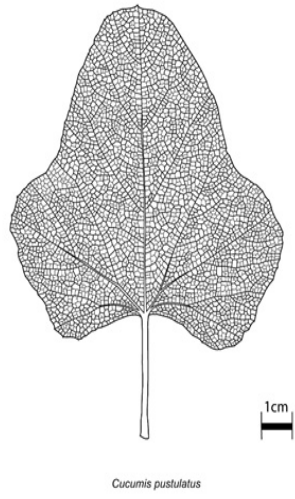

Figure 1b

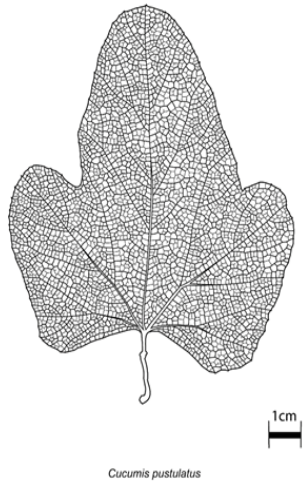

Figure 1a and 1b. Venation patterns and leaf samples of *Cucumis pustulatus.*

Figure 1c

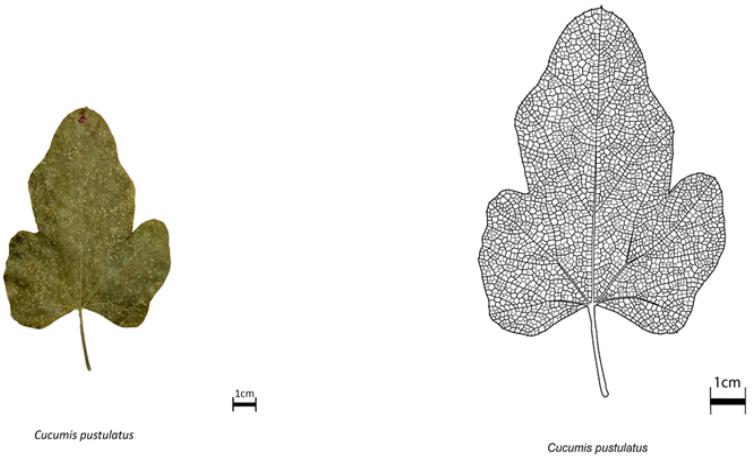

Figure 1c. Venation patterns and leaf samples of *Cucumis pustulatus*.

***Cucumis dipsaceus* Ehrenb. ex Spach (Figures 2a–c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7533 (PBDH), Masungsong and Alcala 7534 (PBDH), Masungsong and Alcala 7536 (PBDH)

Lamina orbiculate with convex apex, odd lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, notophyll with 0.97 to 1.16 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and moderate primary vein; secondary vein craspedodromous with irregular vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

Figure 2a

Figure 2a. Venation patterns and leaf samples of *Cucumis dipsaceus*.

Figure 2b

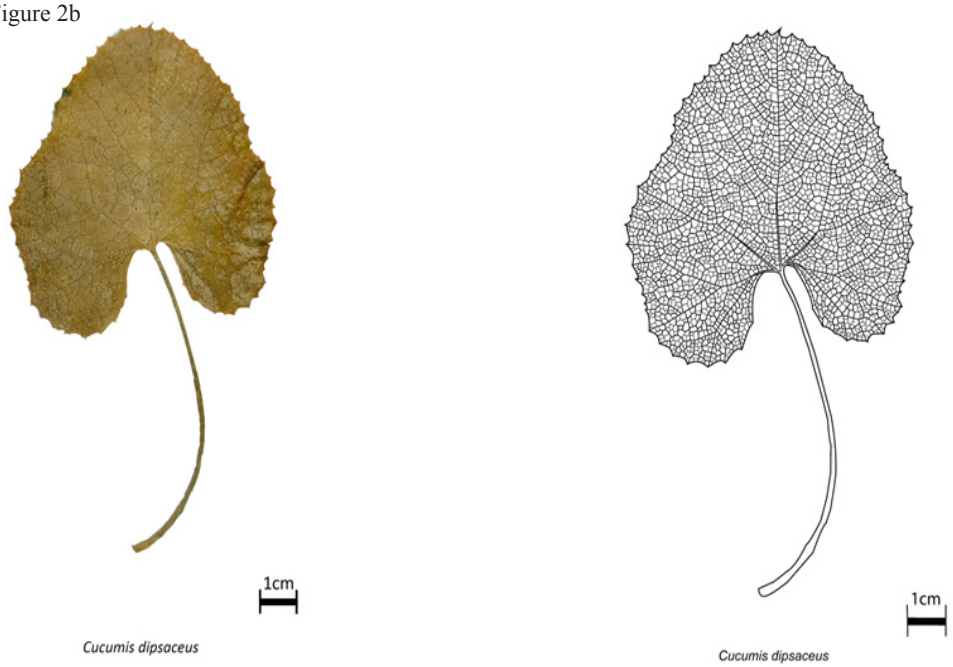

Figure 2c

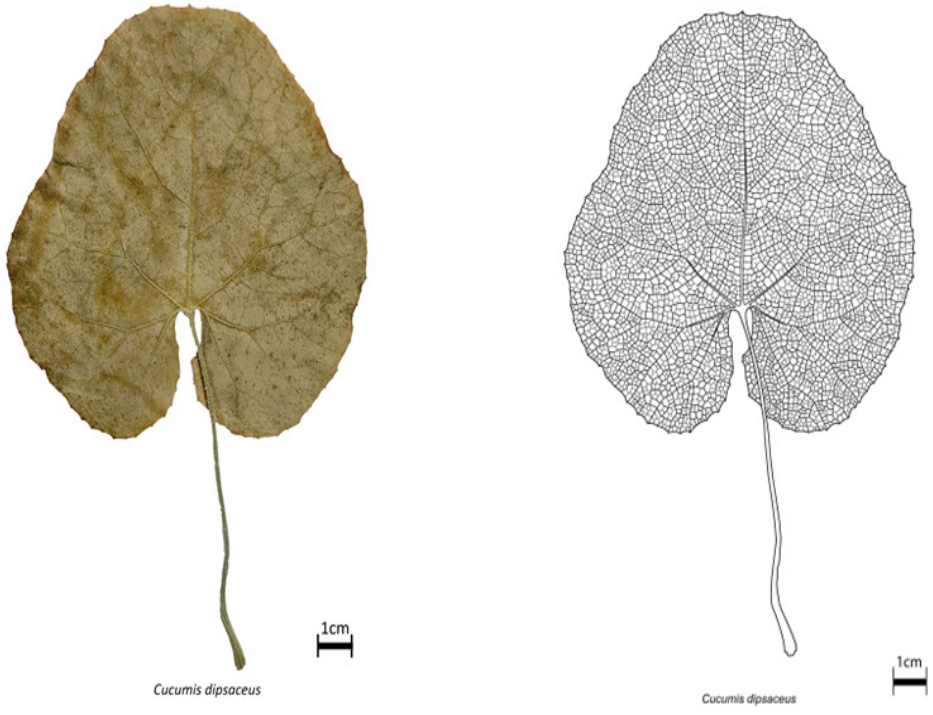

Figure 2b and 2c. Venation patterns and leaf samples of *Cucumis dipsaceus*.

***Cucumis ficifolius* A.Rich**. (**Figures 3a-c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7524 (PBDH), Masungsong and Alcala 7525 (PBDH), Masungsong and Alcala 7526 (PBDH)

Lamina orbiculate with convex apex, odd lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, microphyll to mesophyll with 0.85 to 1.26 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and weak to moderate primary vein; secondary vein craspedodromous with irregular vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

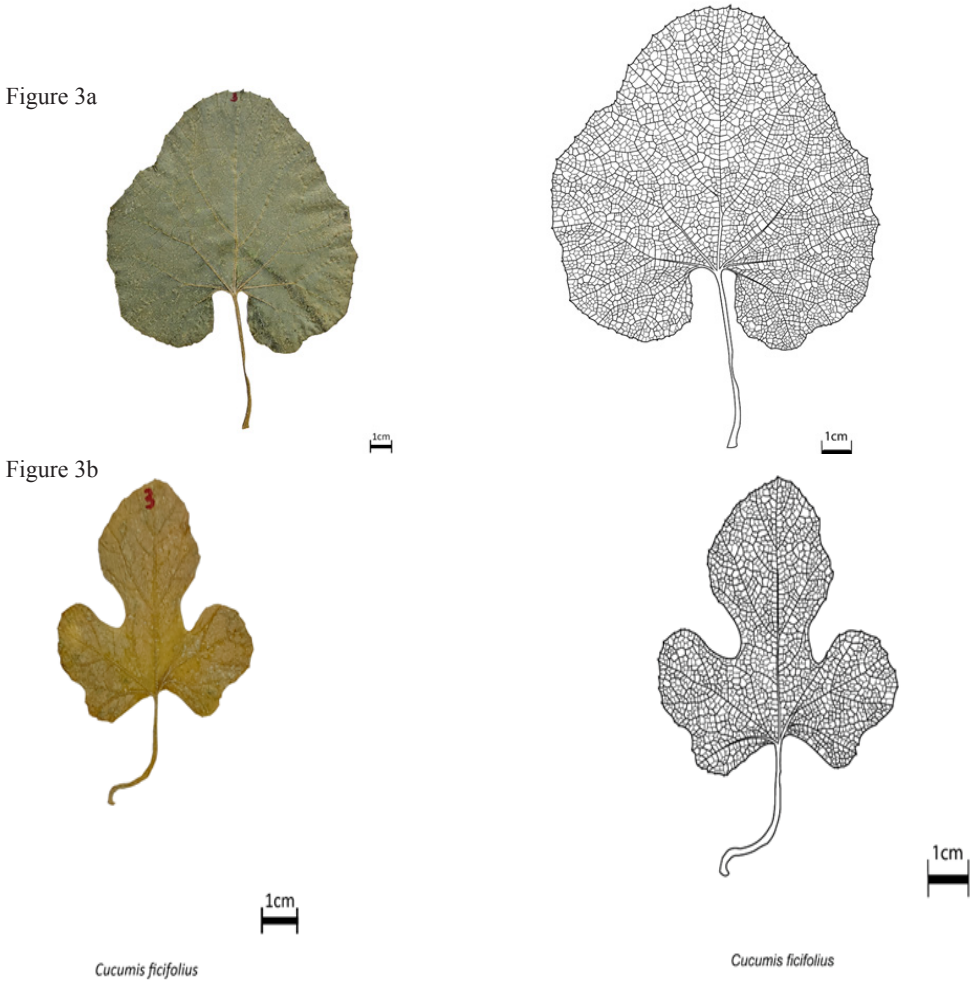

Figure 3a and 3b. Venation patterns and leaf samples of *Cucumis ficifolius*.

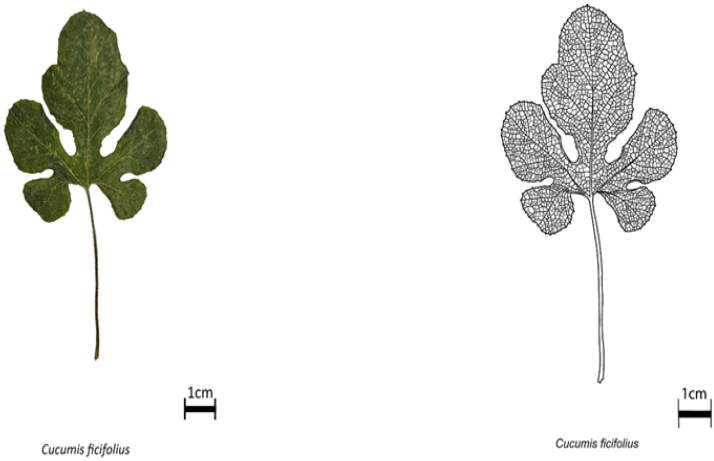

Figure 3c. Venation patterns and leaf samples of *Cucumis ficifolius*.

***Cucumis melo* ssp. *melo* (Figures 4a-c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7541 (PBDH), Masungsong and Alcala 7543 (PBDH), Masungsong and Alcala 7544 (PBDH)

Lamina orbiculate with convex apex, odd lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, mesophyll with 0.88 to 1.11 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and weak primary vein; secondary vein craspedodromous with increasing towards the base vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

Figure 4a

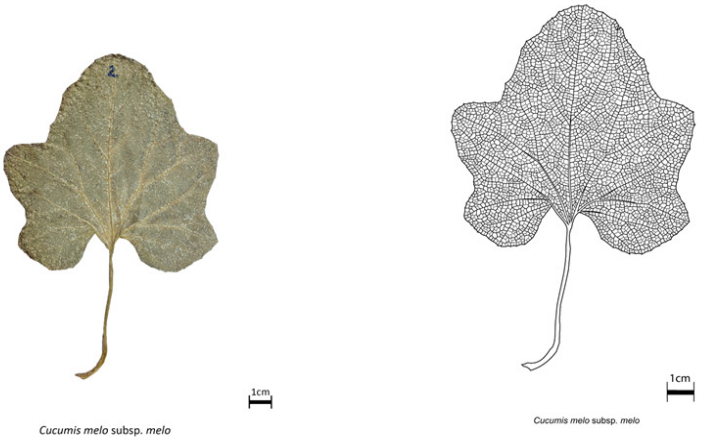

Figure 4a. Venation patterns and leaf samples of *Cucumis melo* ssp. *melo*.

Figure 4b

Figure 4c

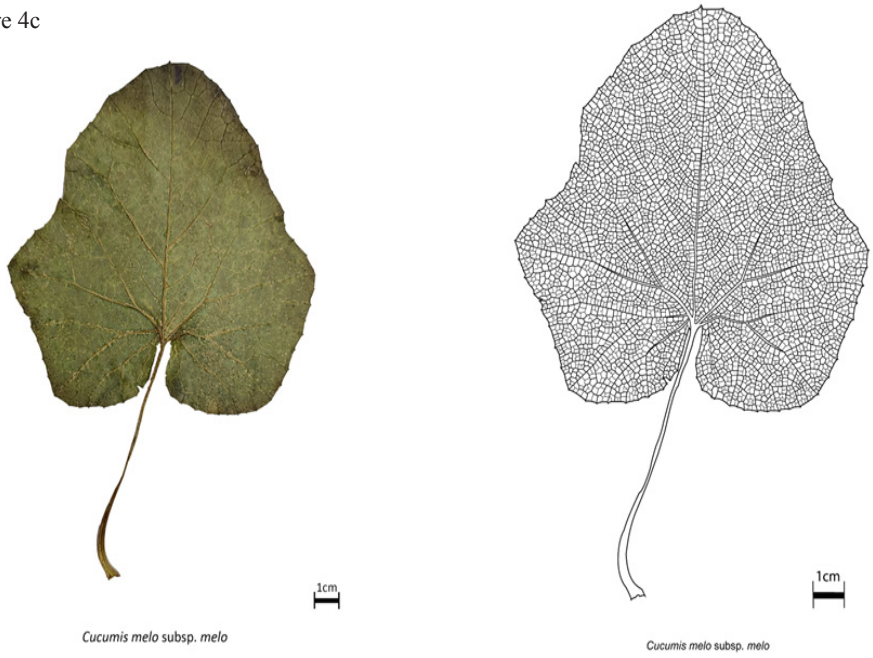

Figure 4b and 4c. Venation patterns and leaf samples of *Cucumis melo* ssp. *melo*.

***Cucumis africanus* L.f. (Figures 5a-c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7520 (PBDH), Masungsong and Alcala 7521 (PBDH), Masungsong and Alcala 7522 (PBDH)

Lamina orbiculate with convex apex, odd-lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, notophyll with 0.97 to 1.60 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and moderate primary vein; secondary vein craspedodromous with irregular vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

Figure 5a

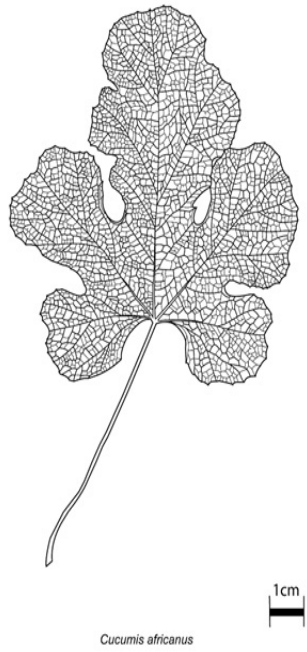

Figure 5b

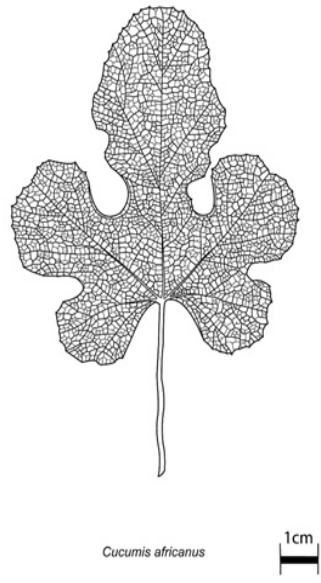

Figure 5a and 5b. Venation patterns and leaf samples of *Cucumis africanus.*

Figure 5c

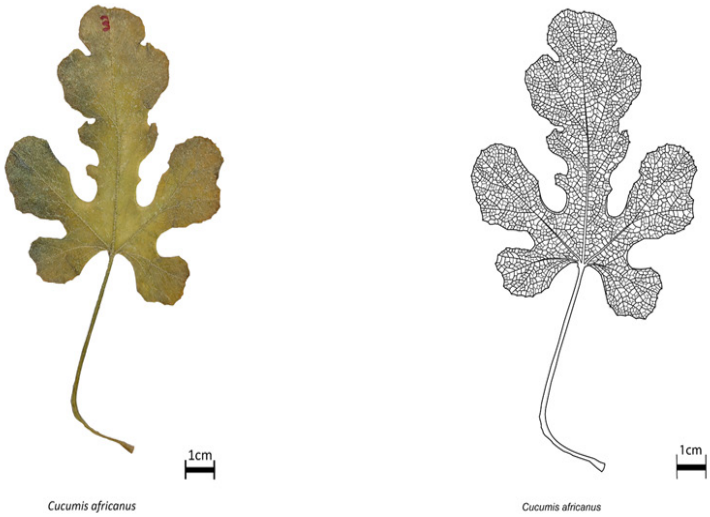

Figure 5c. Venation patterns and leaf samples of *Cucumis africanus.*

***Cucumis myriocarpus* ssp. *myriocarpus* (Figures 6a-c)**

PHILIPPINES • Luzon Island, Municipality of Lipa, Batangas City, Hortanova Farm and Research Center East-West Seed Company Inc., elevation 280m asl, 26 05 2021, Exsicc.-Masungsong and Alcala 7527 (PBDH), Masungsong and Alcala 7528 (PBDH), Masungsong and Alcala 7529 (PBDH)

Lamina orbiculate with convex apex, odd lobed obtuse apex angle, lobate base, wide obtuse base angle and spinose tooth apex, symmetrical, notophyll with 0.95 to 1.53 length to width ratio, serrated, and palmately lobed. Venation actinodromous suprabasal, straight branched and weak to stout primary vein; secondary vein craspedodromous with irregular vein spacing and two pair acute basal secondaries angle; tertiary vein alternate percurrent and angle in relation to primary acute to obtuse; quaternary vein regular polygonal reticulate; marginal ultimate venation looped; areoles well developed.

Figure 6a

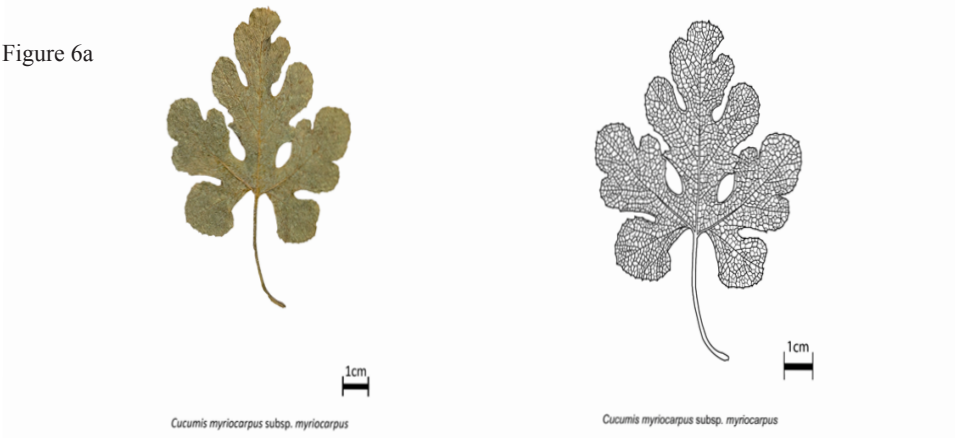

Figure 6a. Venation patterns and leaf samples of *Cucumis myriocarpus* ssp. *myriocarpus*.

Figure 6b

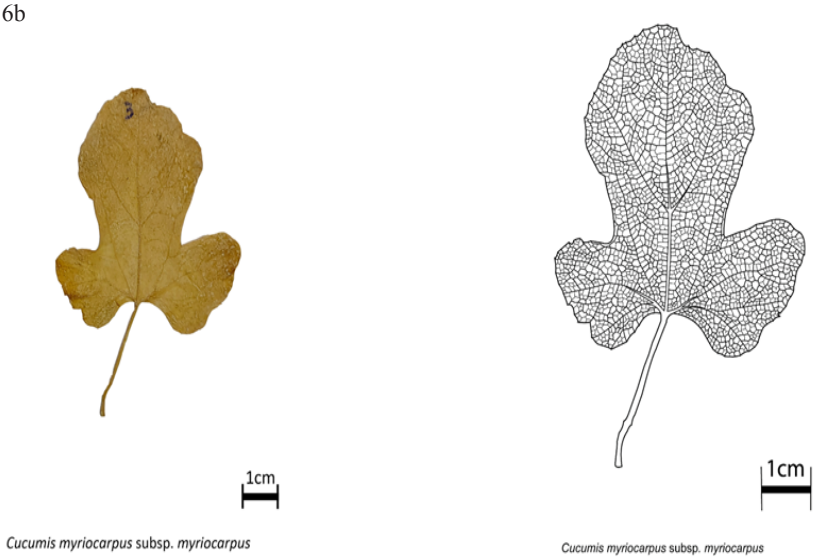

Figure 6c

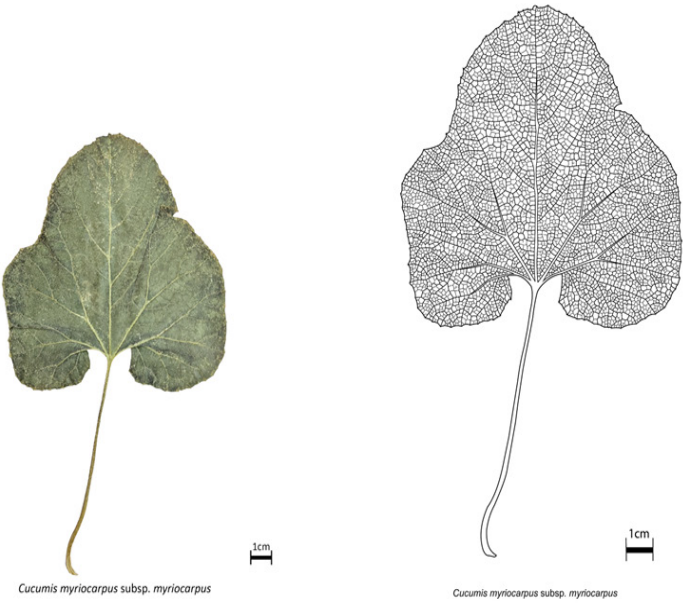

Figure 6b and 6c. Venation patterns and leaf samples of *Cucumis myriocarpus* ssp. *myriocarpus*.

CONCLUSION

Leaf architecture, specifically venation patterns, proves to be a highly valuable tool for the description, differentiation, and classification of the *Cucumis* taxa examined in this study. The effective use of this approach can be extended to other taxa morphologically similar to *Cucumis.* Seed companies or repositories can use the findings of this research as a reference point in streamlining their allocation of space and resources for efficient management and conservation.

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