INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 22, No. 4, p. 26-35, 2023
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

A critical study on wild species of *Solanum* distributed in Dibrugarh District of Assam

Manash Pratim Kashyap[1], Gayatri Deori[2], Ashish Kar[3], Prasenjit Bhagawati[*2]

[1]*Department of Statistics, Assam Down Town University, Guwahati, Assam, India*

[2]*Department of Botany, Assam Down Town University, Guwahati, Assam, India*

[3]*The Energy and Resources Institute (TERI), Assam, India*

Article published on April 16, 2023

Key words: *Solanum*, Wild, Stomatal index, Stomatal diversity, Ethnobotany

Abstract

The genus *Solanum* L. is the largest genus in Solanaceae family, with around 1250 species worldwide. The present study aims to characterize the morphological and anatomical account of six wild species of *Solanum* namely, *S. nigrum* L., *S. americanum* Mill., *S. viarum* Dunal, *S. torvum* Sw., *S. indicum* L., and *S. aethiopicum* L. collected from the district. Variation in stomatal index and stomatal density were observed among the species. The stomatal index varies from 42.85% in *S. viarum* Dunal to 35.29% in *S. americanum* Mill. Similarly, stomatal density varies from 71.33mm^2 in *S. nigrum* L. to 40.76mm^2 in *S. torvum* Sw. and *S. viarum* Dunal respectively. Considering 47 morphological traits and 6 OTUs), a dendrogram was constructed by using a cluster analysis software SPSS 26.0 version which shows *S. nigrum* L. and *S. americanum* Mill. as the most similar having standard Euclidean distance 6 and *S. nigrum* L. and *S. viarum* Dunal as the least similar having standard Euclidean distance 171. Ethnobotanically, out of the six studied species five species *S. nigrum* L., *S. americanum* Mill., *S. torvum* Sw., *S. indicum* L. and *S. aethiopicum* L. were used as vegetables. All the six *Solanum* species are also used to treat problems such as fever, cold and cough, skin diseases, stomach aches, asthma, gastric, burns etc.

[*]Corresponding Author: Prasenjit Bhagawati ✉ prasenjitbhagawati@gmail.com

Introduction

The family Solanaceae is the third most economically important plant taxon and the most profitable in terms of vegetable crops. The family is ecologically and morphologically diverse having 3000 to 4000 species, divided into around 90 genera. Members of the family are found in both the old and new world and are most common and diverse in South America, with Central America and Mexico serving as secondary variety hubs (Cagnato, C, 2018). *Solanum* is the largest genus in Solanaceae family, with around 1250 species worldwide. Though the species of this genus are ubiquitous throughout the world, they are most common in the Southern Hemisphere's tropical and warm temperate zones, particularly in South America. Australia and Africa are two other places where there is a lot of diversity in compared to Europe and Asia (Nidhan *et al*., 2014).

In India, there are 122 taxa (116 species, 2 subspecies, 3 varieties, 1 forma) belongs to 29 genera in the family Solanaceae. The most diverse genus is *Solanum*, having 49 species dispersed across the country. The Eastern ghat is the home to 12 genera and 39 species of Indian Solanaceae, with 17 species belonging to the genus *Solanum* alone. At least 35 species of the Solanaceae family are thought to be present in north-eastern region. The locals mainly the tribal communities consume 15-16 species, as vegetables (Deka *et al,* 2012). Some species of *Solanum* are important source of medicine. (Chidambaram *et al.,* 2022).

The morphological and anatomical features are essential for the standardization of crude drugs. Anatomical characterization for recognition and comparison is an essential taxonomic feature for quality control and certification of medicinal plants. climatic factors have a direct impact on the morpho anatomical structures. These researches on the morph physiological, anatomical and genetic characteristics of industrial and commercial crops, as well as endangered species, are critical for developing effective quality parameter standards and protection methods (Chowdhury *et al.,* 2017).

The purpose of this study is to present a numerical taxonomic analysis of six distinct species of the genus *Solanum* that were collected and identified based on their morphological characteristics. Their anatomical structure, stomatal index and stomatal density had been documented along with ethnobotanical uses of all the species.

Material and methods

Study Area

Sivasagar District is located between 94˚42 and 95˚22 E longitudes and 26˚52 and 27˚12 N latitudes, with an elevation of 86.6m above sea level and a land area of 2886 sq km. The district is bounded on the north by the Brahmaputra River, on the south by Arunachal Pradesh and Nagaland, on the east by the Dibrugarh district and on the west, the Jorhat district and Jhanji River. Forest land makes up 11% of their total land area (Das *et al*., 2016). Sivasagar is home to a large portion the Assam's flora and has become a hotspot of biodiversity due to climate changing and edaphic conditions (Jiji, 2015).

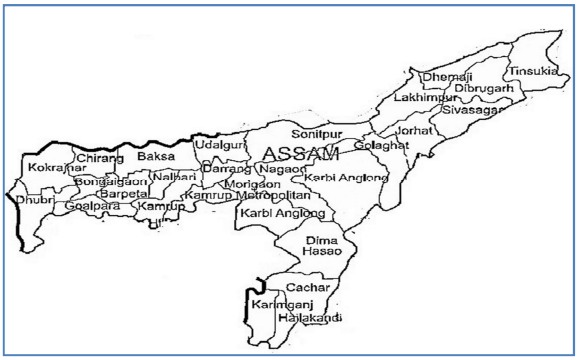

Fig. 1. Map of Assam and its districts.

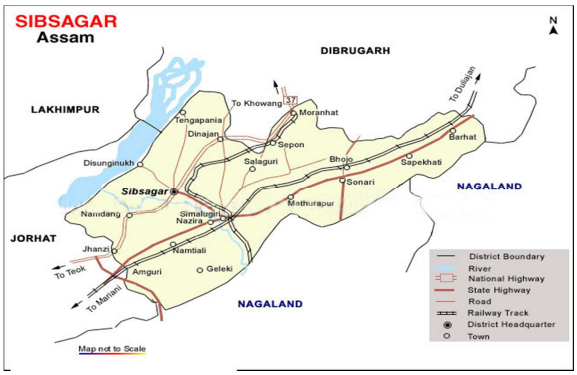

Fig. 2. Different areas of distribution of Wild *Solanum* species of Sivasagar District.

The study was conducted across Sivasagar District. Numerous random field surveys were conducted to collect complete record of diverse habitat, habit, and features of different potions at different phases of development of the species and their occurrence for morphological and anatomical studies. Uses of different wild species of *Solanum* were gathered through questionnaire and interviews. Standard procedures and methodology were used while gathering information on their uses. Herbarium techniques and morpho-anatomical procedures were followed (Das *et al*., 2016).

Collection of specimens

Generally speaking, the collection of specimens for herbarium is anticipated to be a good representative piece of the plant or it may be one whole plant. A good typical specimen suggests that it should be in the reproductive stage, producing leaves as well as flowers and/or fruits. However, that is a challenging task because a significant number of species experience vegetative development and flowering at different times of the year. Once more, some characters are only accessible during the active vegetative stage or even during the perpetual winter or draught. Once the sample has been taken, it must be preserved in a "vasculum" or, in the absence of one, in excellent polythene bags with the mouth kept shut and preferably secured with a rubber band or piece of thread. During the dry season, a small amount of water should be poured inside the bad, and before tying it, one should inflate it with their lips. By doing this, the possibility of injury from external pressure is reduced.

Identification

When we see any item, whether living or not, we attempt to identify it and refer to it by name. Identification is this efforts main component. To identify a plant species, first examine its characteristics, cross-reference them with the flora of the region, go through the family, genus, and species keys, and compare them to the full description and illustration. Following that, it must be carefully compared to previously identified plants of the species or variety.

Morphological data analysis

47 morphological characters were noted for the taxa under study on six OTUs. Character states were established through examination of both herbarium and fresh specimens, and they were used as multistate characters. SPSS was used to perform cluster analysis on the data matrix (26.0version). To clarify the implied evolutionary links between the species, the dendrogram (Fig. 3) was developed (Kumar *et al.,* 2019; Deka *et al*., 2023).

Anatomical study

The experiment was carried out in the Botany laboratory of Assam down town University. Stem of these species were collected and washed thoroughly with tap water before starting the process. The stems were sectioned freely using razor blades and thin slices were stored in water before transferring to watch glass. After that the thin sections were transferred to a glass slide. Double staining procedure is followed using a few drops of safranin solutions and few drops of fast green solution. The excess amount of both solutions safranin and fast green were washed off using water before adding a dab of glycerine to the slide and covered with coverslip and observed under microscope. This process has been repeated for all the plant specimens (Al-Hadeethi *et al*., 2021).

Determination of stomatal density

Collect the appropriate leaf material/plant part, wash it gently under running water to eliminate any dust or debris, and dry it. A thin epidermal layer was peeled off by using suitable replica like quick fix. After that the peeled off replica is taken in a glass slide and by using by using water glycerol or water the replica is spread properly and cover it using a coverslip.

The similar procedure should be repeated for all the different leaves for both sides of the leaves. Now, it is possible to record the number of stomata present in a microscopic view field in order to calculate the stomatal density, which is given in stomata/mm^2.

Count the total number of stomata visible in the circular view field of the microscope at a given

magnification. Using ocular scale determine the diameter of the view field. The area of the circle in a microscopic view field can be calculated by using the formula: πr^2 where, r is the radius of circle or the view field, i.e., ½ of circle's diameter. Now, number of stomata formm^2 of area of both surface of the leaves can be calculated.

Determination of stomatal index

Stomatal index can be determined by using the formula, stomatal index (%) = (S/S+E) × 100 where, S is the number of stomata and E is the epidermal cells in microscopic view field. Stomatal index can also be determined for both the surfaces of the leaves like stomatal density (Paul *et al.,* 2017).

Result and discussion

Table 1. Collection details of wild *Solanum* species from different sites of Sivasagar district.

SN	Scientific Name	Local Name	Location	Gps
1.	*Solanum nigrum* L.	Los kochi	Richai	27.14147˚N; 94.745967˚E
			Demow	27.123776˚N; 94.758516˚E
			Sivasagar	27.127998˚N; 94.756002˚E
2.	*Solanum americanum Mill.*	Los kochi	Kachari Pathar	27.10163˚N; 94.714292˚E
			Raichai	27.141499˚N; 94.745978˚E
			Demow	27.123776˚N; 94.758516˚E
3.	*Solanum viarum* Dunal	Penmedhi	Paroli Guri to Bahuwa Bari Rd	27.215472˚N; 94.714292˚E
			Demow	27.123899˚N; 94.758899˚E
			Nowjan Tongia	27.213473˚N; 94.722094˚E
4.	*Solanum torvum* Sw.	Hati bhekuri	Sivasagar	27.121232˚N; 94.738587˚E
			Rachai	27.139716˚N; 94.744298˚E
			Demow	27.123776˚N; 94.758516˚E
5.	*Solanum indicum* L.	Tit-bhekuri	Kachari Pathar	27.10163˚N; 94.714292˚E
			Rachai	27.139716˚N; 94.744298˚E
			RL. Rd.	27.140438˚N; 94.740851˚E
6.	*Solanum aethiopicum* L.	Bhekuri-bengena	Bam Rajabari Rd	27.19453˚N; 94.669241˚E
			Demow	27.123776˚N; 94.758516˚E
			Sivasagar	27.127998˚N; 94.756002˚E

Table 2. Morphological characters and character states used in numerical analysis.

SN	Characters	Taxa					
		S. indicum	*S. torvum*	*S. viarum*	*S. aethiopicum*	*S. americanum*	*S. nigrum*
1	Habit (Shrub 1/Herb 2)	1	1	1	2	2	2
2	Plant height(in m) (Upto 1m 1/Upto 1-1.5m 2/Upto 2-2.5m 3)	2	3	2	3	2	1
3	Stem surface(Coarse 1/Glabrous to sparsely pubescent 2/ Pubescent 3)	1	1	3	3	2	2
4	Structure of stem(Thick 1/ Slender 2)	1	1	1	1	2	2
5	Nature of stem(Erect 1/ Weak 2)	1	1	1	1	1	2
6	Type of stem(Woody 1/Herbaceous 2)	1	1	1	2	2	2
7	Stem colour(Green 1/ Grey-green 2/ Green-brown 3)	3	2	3	3	1	1
8	Leaf spine (Present 1/Absent 2)	1	1	1	2	2	2
9	Leaf shape(Ovate 1/Obovate 2/ Elliptic 3/ Oblong 4)	1	1	1	1	1	1
10	Leaf apex(Acute 1/ Acuminate 2/ Obtuse 3)	1	1	1	1	1	1
11	Leaf margin(Entire-sinuate 1/ Sinuate-lobed 2/ Lobed 3)	2	2	3	2	1	1
12	Leaf base(Cordate 1/Cordate -sub cordate 2/ Cordate-obliquely sub cordate 3/ Obliquely sub cordate 4/ Cuneate-obtuse 5)	3	4	1	2	5	5
13	Leaf adaxial surface(Sparsely pubescent 1/ Stellate pubescent 2/ Stellate tomentose 3)	3	3	2	2	1	1
14	Leaf abaxial surface(Sparsely pubescent 1/ Stellate pubescent 2/ Stellate tomentose 3)	3	3	2	2	1	1
15	Hair frequency on adaxial surface(Dense 1/ Sparse 2)	2	2	1	1	2	2
16	Hair frequency on abaxial surface(Dense 1/ Sparse 2)	1	1	1	1	2	2
17	Leaf length(incm)(4.65cm 1/4.99cm 2/6.59cm 3/10.65cm 4/12.26cm 5/13.41cm 6)	3	5	4	6	2	1
18	Leaf width(incm)(2.34cm 1/2.7cm 2/5.23cm 3/7.52cm 4/9.43cm 5/10.17cm 6)	3	6	5	4	2	1
19	Leaf stalk(Petiolate 1/ Sessile 2)	1	1	1	1	1	1
20	Petiole length(incm)(1.57cm 1/2.61cm 2/2.66cm 3/2.97cm 4/3.88cm 5/5.53cm 6)	4	5	6	3	2	1
21	Petiole surface(Glabrous 1/ Pubescent 2)	2	2	2	2	2	2
22	Pedicel length(incm)(0.5cm 1/0.6cm 2/0.7cm 3/1cm 4)	4	4	2	3	1	1
23	Pedicel surface(Glabrous 1/ Pubescent 2)	2	2	2	2	2	2
24	Corolla colour(White 1/ Violet colour with white midrib 2)	2	1	1	1	1	1
27	Corolla diameter(incm)(0.7cm 1/1.5cm 2/1.8cm 3/2-2.5cm 4)	3	4	2	4	1	1
28	Corolla sinus(Shallow 1/ Deep 2)	1	1	1	1	1	1
29	Corolla surface outside(Glabrous 1/ Pubescent 2)	2	2	2	2	2	2
30	Calyx length(incm)(0.3cm 1/0.5cm 2/0.8cm 3/0.9cm 4/2cm 5)	4	3	2	5	1	1
31	Calyx surface(Glabrous 1/ Pubescent 2)	2	2	2	2	2	2

SN	Characters	Taxa					
		S. indicum	*S. torvum*	*S. viarum*	*S. aethiopicum*	*S. americanum*	*S. nigrum*
32	Calyx(Prickly 1/ Not prickly 2)	1	1	1	2	2	2
33	Calyx sinus(Deep 1/ Shallow 2))	1	1	1	2	2	2
34	Anther length(incm)(0.1cm 1/0.5cm 2/0.6cm 3/0.7cm 4/0.8cm 5)	2	3	4	5	1	1
35	Stamen length(incm)(0.2cm 1/0.6cm 2/0.7cm 3/0.8cm 4)	2	3	4	3	1	1
36	Style length(incm)(0.3cm 1/0.5cm 2/0.6cm 3/0.8cm 4/1cm 5)	2	4	5	3	1	1
37	Style surface(Glabrous 1/ Pubescent 2)	2	1	1	2	2	2
38	Floral aestivation(Valvate 1/ Imbricate 2)	1	1	1	1	2	2
39	Inflorescence(Axillary cyme 1/ Supra-axillary 2/Racemose cyme 3/ Scorpioid cyme 4/ Umbellate cyme 5)	4	2	1	3	5	5
40	Number of flowers per inflorescence (2-3) 1/(3-5) 2/(4-7) 3	2	3	1	2	2	2
41	Unripe fruit colour(Green 1/Pale green 2/Green with white lining 3/White mottled with green veins 4)	3	2	4	1	1	1
42	Ripe fruit colour(Yellow 1/ Yellow-orange 2/ Glossy black 3/ Dull black 4)	2	1	1	2	3	4
43	Fruit diameter(incm)(0.6cm 1/0.9cm 2/1.2cm 3/2.1cm 4/2.5cm 5)	2	3	4	5	1	1
44	Fruit shape(Globose berry 1/ Oblate 2)	1	1	1	2	1	1
45	Fruit surface(Glabrous 1/Glabrescent 2)	1	1	1	1	1	1
46	Seed colour(Brown 1/ Pale brownish 2)	1	1	1	2	2	2
47	Frequency of seed(Numerous 1/ Few 2)	1	1	1	1	1	1

Analysis

In general, the pentamerous and normal blooms of *Solanum* are easily recognised by their equal stamens that dehisce by terminal pores. A distinctive feature of many Solanaceae species, particularly those in the genus Solanum, is the dehiscence of anthers through tiny apical holes. These divisions are all based on morphological traits. For taxonomical reorganisations within the Genus *Solanum*, several general suggestions were given. The taxonomy of *Solanum* species relied mostly on morphological traits. Identification of the species is greatly aided by plant behaviours, stem structure, leaf shape, margin, apex and base, petiole pubescence, flower colour and structure, fruit, and seed. In cluster analysis, 47 morphological features are analysed and employed (Kumar *et al.*, 2019).

Table 3. Morphological variations between the studied species based on Square Euclidean distance.

Proximity Matrix						
Case	Squared Euclidean Distance					
	1:*S.indicum*	2:*S.torvum*	3:*S.viarum*	4:*S.aethiopicum*	5:*S.americanum*	6:*S. nigrum*
1:*S.indicum*	0.000	35.000	65.000	56.000	66.000	82.000
2:*S.torvum*	35.000	0.000	44.000	47.000	115.000	147.000
3:*S.viarum*	65.000	44.000	0.000	61.000	143.000	171.000
4:*S.aethiopicum*	56.000	47.000	61.000	0.000	118.000	142.000
5:*S.americanum*	66.000	115.000	143.000	118.000	0.000	6.000
6:*S. nigrum*	82.000	147.000	171.000	142.000	6.000	0.000

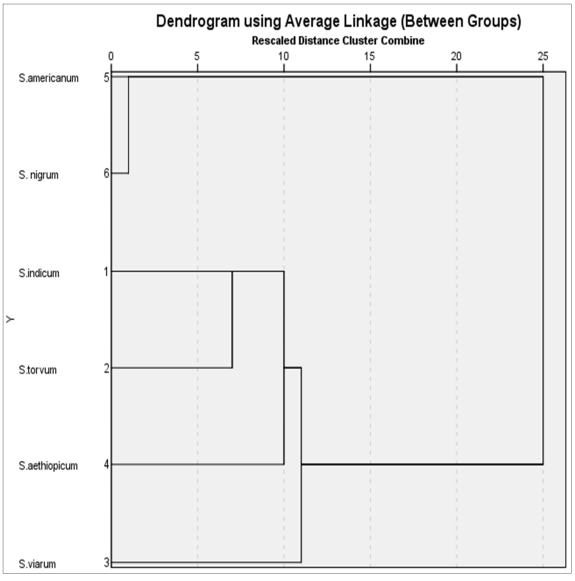

Fig. 3. Dendrogram showing clusters.

Dendrogram

The dendrogram is consists of mainly two clusters. One cluster comprises of *S. americanum* and *S. nigrum* and the second cluster comprises of *S. indicum, S. torvum, S. viarum, S. aethiopicum*. The second cluster is again extended into two clusters. The first cluster comprising of *S.americanum* similar to *S. nigrum* as shown in the cluster analysis has the lowest morphological variation 6.000. *S.americanum* and *S. nigrum* characterized by white flower and are differentiated by angular stem and shiny berry and round stem and dull berry respectively. *S.nigrum* highly dissimilar to *S.viarum* as shown in the cluster analysis has the greatest morphological variation 171.000. *S. nigrum* characterized by small white

flower and leaf surface sparsely pubescent while *S. viarum* characterized by comparatively big white flower than *S. nigrum* and leaf surface stellate pubescent. The cluster analysis shows that *S. americanum* and *S. nigrum* are significantly different than the other studied species *S. indicum, S. torvum, S. viarum*, *S. aethiopicum*.

Though these four studied species *S.indicum, S.torvum, S.viarum, S.aethiopicum* are under one cluster but again *S.indicum* and *S.torvum* are under another cluster, *S.torvum, S.indicum*, *S.aethiopicum* are under another cluster and *S.viarum* is somewhat difference than the other two clusters. *S.indicum* and *S.torvum* are characterized by stellate tomentose on the leaf surface and are differentiated by their flower colour, violet and white respectively. *S.indicum, S.torvum* and *S.aethiopicum* are characterized by petiole and pedicel surface having pubescent and differentiated by inflorescence and presence of prickles at the calyx surface. *S.viarum* is differentiated from the other clusters by their inflorescence and presence of stellate pubescent. Despite recent intensive research on the genus Solanum, taxonomy is still unclear and under discussion due to inter- and intraspecific hybridization, morphological plasticity, and polyploidization.

Stem anatomical study

The outline of stem is made up of a uniseriate epidermis which is covered with cuticles. Trichomes are present at the cuticles. The cortex is divided into two layers, the first of which is found beneath the epidermis and is made up of collenchymas tissue, and the second of which is made up of parenchyma. Vascular bundles are present and is made up of xylem and phloem. The heart of the stems pith is filled with parenchyma cells, and the circular cells and typical schizogenous intercellular space between them are consistent with the results (Al-Hadeethi *et al.*, 2021; Nurit-Silva *et al.,* 2011).

Solanum nigrum L.

The outline stem has a tetragonal shape, and the cross section of the stem is made up of a uniseriate epidermis which is covered with cuticles. The cortex is divided into two layers, the first of which is found beneath the epidermis and is made up of collenchyma tissue, and the second of which is made up of parenchyma. The stem shaped vascular bundles are open and collateral, made up of phloem and xylem. The heart of the stems pith is filled with parenchyma cells, and the circular cells and typical schizogenous intercellular space between them are consistent with the results.

Solanum americanum Mill.

The outline stem has a tetragonal shape, and the cross section of the stem is made up of a uniseriate epidermis which is covered with cuticles. The cortex is divided into two layers, the first of which is found beneath the epidermis and is made up of collenchymas tissue, and the second of which is made up of parenchyma. The stem shaped vascular bundles are open and collateral, made up of phloem and xylem. The heart of the stems pith is filled with parenchyma cells, and the circular cells and typical schizogenous intercellular space between them are consistent with the results.

Solanum viarum Dunal

The secondary growth stem is having a uniseriate epidermis having irregular epidermal cells covered in a thin and wavy cuticle layer having glandular trichomes. The cortex is made up of two layers, first is beneath the epidermis and is made up of collenchymatous tissues of 4-5 layers and the second layer is made up of parenchymatous cells of 5-6 layers. The stem shaped vascular bundles are open and collateral, made up of phloem and xylem. The heart of the stems pith is filled with parenchyma cells and intercellular space between them.

Solanum torvum Sw

The secondary growth stem has a nearly circular cross section and a 1-layered epidermis having quadrangular cells that are covered in a thin and smooth cuticle. Sessile, stalked porrect-stellate trichomes with a sparse and subsessile trichome, decreased mid-point. An angular collenchyma of 5-8 layers that forms a continuous cylinder is followed by

a 4-5 layers decreased cortical parenchyma. External xylem, phloem, and internal phloem make up the vascularisation which is surrounded by a sheath of perivascular on the outside. A 3-4 layered cambial zone is visible next to the internal phloem, and the xylem is lignified, positioned as a large and continuous cylinder with vessel elements distributed radially between the lignified fibres. The medullar parenchyma is made up of spherical cells with thin walls.

Solanum indicum L.

The secondary growth stem has a nearly circular cross section and a 1-layered epidermis having quadrangular cells that are covered in a thin cuticle having non-glandular trichome. The cortex is made up of two layers, first is beneath the epidermis and is made up of collenchymatous layer and the second layer is made up of parenchymatous cells. The stem shaped vascular bundles are open and collateral, made up of phloem and xylem. The heart of the stems pith is filled with parenchyma cells and intercellular space between them.

Solanum aethiopicum L.

The secondary growth stem is having a uniseriate epidermis having irregular epidermal cells covered in a thin cuticles having non-glandular trichomes. The cortex is made up of two layers, first is beneath the epidermis and is made up of collenchymatous layer and the second layer is made up of parenchymatous cells. The stem shaped vascular bundles are open and collateral, made up of phloem and xylem. The heart of the stems pith is filled with parenchyma cells and intercellular space between them.

The anatomical study shows that all the studied *Solanum* species shows the layer like cuticles followed by epidermal layer. The cortex is divided into collenchymatous and parenchymatous layers respectively. The vascular bundle is consisting of phloem and xylem. The pith known to be the heart of stem is filled with parenchymatous cells having intercellular space between them. These layers are more or less similar to each other and cab be slightly different in the thickness of the layers.

Trichomes

Solanum nigrum L. have both glandular and non-glandular trichomes; the later are multicellular, uniseriate, and peltate. There are also few short glandular trichomes, however they are sparsely dispersed (Bello *et al*., 2017).

On both the epidermal surfaces, non-glandular, multicellular, uniseriate trichomes can be seen (Mandal, 2019). Non-glandular with unicellullar or multicellular trichomes.

Solanum americanum Mill having non-glandular trichomes that are multicellular uniseriate. (Bello *et al*., 2017). Non-glandular with unicellullar or multicellular trichomes.

In *Solanum viarum* Dunal both surfaces, there are glandular and non-glandular, uniseriate, multicellular trichomes with a bulbous base and a pointed apex, as well as stellate, 5-branched, non-glandular trichomes (Sutapa *et al*., 2015). Presence of long conical glandular and non-glandular, unicellular and multicellular trichomes on both the surfaces.

In *Solanum torvum* Sw. there are numerous, widely dispersed non-glandular trichomes of various sorts, including those that are rotate-stellate, unicellular, uniseriate, and 2 to 5 armed (Bello *et al*., 2017). Both the epidermal surfaces have non-glandular, stellate trichomes with 3-8 branches (Sutapa *et al*., 2015).

Both the surfaces have non-glandular branched, multi angulate, or 4-8 armed stellate trichome, unicellular or multicellular.

Solanum indicum L. have non-glandular, unicellular, branched, multi angulate, or 3-7 armed stellate trichomes on both the surfaces.

Solanum aethiopicum L have non-glandular trichomes to be uniseriate, unicellular, rotating to multi angulate, or 3 to 5 armed stellate trichomes that are sparsely dispersed (Bello *et al*., 2017). Non-glandular, unicellular, 4 to 8 armed stellate trichome.

Stomatal index and stomatal density

Table 4. Stomatal index of studied species.

SN	Scientific name	Leaf surface	No. of stomata	No. of epidermal cells	Stomatal index (%)
1.	*Solanum nigrum* L.	Adaxial	48	72	40
		Abaxial	56	96	36.8
2.	*Solanum americanum* Mill.	Adaxial	40	60	40
		Abaxial	48	88	35.29
3.	*Solanum viarum* Dunal	Adaxial	32	56	36.36
		Abaxial	48	64	42.85
4.	*Solanum torvum* Sw.	Adaxial	32	48	37.5
		Abaxial	40	64	38.46
5.	*Solanum indicum* L.	Adaxial	36	52	40.90
		Abaxial	40	60	40
6.	*Solanum aethiopicum* L.	Adaxial	40	56	41.67
		Abaxial	44	80	35.48

Table 5. Stomatal density of studied species.

SN	Scientific name	Leaf surface	Stomatal density
1.	*Solanum nigrum* L.	Adaxial surface	61.14
		Abaxial surface	71.33
2.	*Solanum americanum* Mill.	Adaxial surface	52.77
		Abaxial surface	61.14
3.	*Solanum viarum* Dunal	Adaxial surface	40.76
		Abaxial surface	61.14
4.	*Solanum torvum* Sw.	Adaxial surface	40.76
		Abaxial surface	50.95
5.	*Solanum indicum* L.	Adaxial surface	45.85
		Abaxial surface	50.95
6.	*Solanum aethiopicum* L.	Adaxial surface	50.96
		Abaxial surface	56.05

Table 6. Ethnobotanical uses of the studied species.

SN	Scientific name	Ethnobotanical uses
1.	*Solanum nigrum* L.	Young shoots and leaves can be used as vegetables. Ripe fruits are also edible. Used against gastric, cancer, snake bite, burns, stomach aches or ulcers, cough, asthma, skin diseases, tuberculosis.
2.	*Solanum americanum* Mill.	Leaves and young shoots are used as vegetables. Used to expel worms, to treat deep wounds, ulcer, cancer, skin diseases, to improve kidney functions.
3.	*Solanum viarum* Dunal	Used to treat chronic asthma, skin disease, obesity.
4.	*Solanum torvum* Sw.	Used to treat colds and coughs, fever, tooth decay, asthma, diabetes, liver diseases, tuberculosis, to cure cracked foot, wounds, fruits are used as vegetable.
5.	*Solanum indicum* L.	It is used to treat asthma, chest pain, chronic fever, dry cough, difficult urination.
6.	*Solanum aethiopicum* L.	Leaves and fruits are used as vegetables. Used to treat asthma, skin infections, swollen joint pain, constipation.

Anifat O. Bello *et. al* (2017) had found that among the ten *Solanum* species studied *S.gilo* has the highest stomatal index 25.08% and S.wrightii has the lowest stomatal index 10.18% on the adaxial surface. *S.aethiopicum* has the highest stomatal index 33.49% and *S.erianthum* has the lowest stomatal index 12.23% on the abaxial surface(Bello *et al.*, 2017). Among the six *Solanum* species studied here *S.aethiopicum* has the highest stomatal index 41.67% and *S.viarum* has the lowest stomatal index 36.36% on the adaxial surface. *S.viarum* has the highest stomatal index 42.85% and *S.americanum* has the lowest stomatal index 35.29% on the abaxial surface. Ishfaq Hameed *et al.* (2011) had studied stomatal density of five species of Solanaceae and found out that *S.nigrum* has the highest stomatal density 70.30mm^2 and *W.coagulans* has the lowest stomatal density 12mm^2 on the adaxial surface. *S.nigrum* has the highest stomatal density 77.8mm^2 and *W.coagulans* has the lowest stomatal density 7mm^2 on the abaxial surface.

Among the six *Solanum* species studied here *S.nigrum* has the highest density 61.14mm² and *S.viarum* and *S.torvum* has the lowest density 40.76mm ²on the adaxial surface. *S.nigrum* has the highest density 71.33mm ² and *S.torvum* and *S.indicum* has the lowest density 50.95mm ² on the abaxial surface.

Conclusion

In this study the diversity of five different *Solanum* species using morphological, anatomical characters that can be used for taxonomic delimitation. The data obtained could be combined with data from other sources, like molecular taxonomic techniques, to enhance proper taxonomic revision of six *Solanum* species. In conclusion, this study was successful in highlighting a number of morphological characters that can be used for taxonomic delimitation of *Solanum* species. A detailed study of *Solanum* species for further evaluation by using modern taxonomic trends such as biochemical study, palynology is needed to properly classify and enhance the importance of the various *Solanum* species.

References

Al-Hadeethi MA, Al-Taie AT, Al-Rawi AF. 2021. Anatomical study of *Solanum nigrum* L. from Solanaceae family growing in Iraq. Journal of Physics: Conference Series **1879(2),** 022003.

Bello AO, Oladipo OT, Saheed SA. 2017. Leaf epidermal studies of some Solanum (Solanaceae) species in Nigeria. Phytologia Balcanica **23(1),** 55-63.

Cagnato C. 2018. Shedding light on the nightshades (Solanaceae) used by the ancient Maya: A review of existing data, and new archeobotanical (macro-and microbotanical) evidence from archeological sites in Guatemala. Economic Botany **72,** 180-195.

Chidambaram K, Alqahtani T, Alghazwani Y, Aldahish A, Annadurai S, Venkatesan K Kavitha D, Ellappan T, Krishnaraju V, Premalatha P, Rajalakshimi V, Geetha K. 2022. Medicinal Plants of Solanum Species: The Promising Sources of Phyto-Insecticidal Compounds. Journal of Tropical Medicine **2022,** 1-22.

Chowdhury T, Mandal A, Roy SC, De Sarker D. 2017. Diversity of the genus *Ocimum* (Lamiaceae) through morpho-molecular (RAPD) and chemical (GC-MS) analysis. Journal of Genetic Engineering and Biotechnology **15(1),** 275-286.

Das D, Kar A, Nath D, Das AB, Hatimuriya R, Raidongia L, Boruah J. 2016. Diversity and uses of Solanaceous plants in Sivasagar District of Assam, India. Pleione **10(2),** 226-238.

Deka BC, Thirugnanavel A, Patel RK, Nath A, Deshmukh N. 2012. Horticultural diversity in Northeast India and its improvement for value addition. Indian Journal of Genetics and Plant Breeding **72(2),** 157.

Deka L, Kar A, Bhagawati P. 2023. A critical study on genus Ocimum of Dibrugarh District of Assam. International Journal of Biosciences **22(2),** 248-259.

Hameed I, Hussain F. 2011. Stomatal studies of some selected medicinal plants of family Solanaceae. Journal of Medicinal Plants Research **5(18),** 4525-4529.

Jiji P. 2015. Endangered plants and their uses of Sivasagar District, Assam, India. International Research Journal of Biological Sciences **4(7),** 15-18.

Kumar K, Raj A, Sivakumar K. 2019. Etnobotanical Studies on Solanum species from Nilgiri Biosphere Reserve of Western Ghats, Tamil Nadu, India. World Scientific News **115,** 104-116.

Mandal K, Dobhal Y, Joshi BC. 2019. An Updated Review on Solanum viarum Dunal. Recent Trends in Pharmaceutical Sciences and Research **2(1),** 1-6.

Nidhan SB, Vashistha BD. 2014. Genus L. in North and North-eastern Haryana (India): Diversity, Solanum ecological status and ethnobotanical significance. Genus **1(1&2),** 31-42.

Nurit-Silva K, Costa-Silva R, Coelho VP, Agra MD. 2011. A pharmacobotanical study of vegetative organs of Solanum torvum. Revista Brasileira de Farmacognosia **21,** 568-74.

Paul V, Sharma L, Pandey R, Meena RC. 2017. Measurements of stomatal density and stomatal index on leaf/plant surfaces. Manual of ICAR Sponsored Training Programme for Technical Staff of ICAR Institutes on Physiological Techniques to Analyze the Impact of Climate Change on Crop Plants 27-30.

Sutapa C, Rahaman CH, Sudhendu M. 2015. Ethno-botanical study of some Solanum L. species with reference to foliar micromorphology and wood elements. International Journal of Current Microbiology and Applied Sciences **4(8),** 582-596.