



## RESEARCH ARTICLE

### Morphological Characterization of Wild *Solanum* Species Used for Grafting in Brinjal (*Solanum melongena* L.)

Senthilvadvu G<sup>1\*</sup>, Pugalendhi L<sup>1</sup>, Saraswathi T<sup>1</sup>, Raguchander T<sup>2</sup>, Shanthi A<sup>2</sup> and Jeyakumar P<sup>2</sup>

<sup>1\*</sup>Horticultural College and Research Institute, TNAU, Coimbatore, India

<sup>2</sup> Agricultural College and Research Institute, TNAU, Coimbatore, India

Corresponding author mail id: [gvadivuguruswamy@gmail.com](mailto:gvadivuguruswamy@gmail.com)

#### ABSTRACT

*Solanum* L. (Solanaceae) is one of the largest genera of angiosperms, where subgenus *Leptostemonum* consists of one-third of its economically important species. However, the group faces difficulty in species identification due to the lack of a regional key to each species. As *Solanum* species carry out traits for resistance to disease, pests, and nematodes, hassle in species identification hinders their utilization. Hence this study provides a detailed morphological characterization of five *Solanum* species which bring forth a clear identification of the species and may further be exploited for improvement program in brinjal.

**Keywords:** *Solanum*; *Leptostemonum*; *Brinjal*; *Grafting*; *Morphology*

#### INTRODUCTION

Brinjal (*Solanum melongena* L., 2n = 24), belonging to the family Solanaceae is a native crop of India, with China as its secondary center of origin. *Solanaceae* comprises 3000 species distributed in some 90 genera (Vorontsova and Knapp, 2012). Out of these 90 genera, *Solanum* L. is the largest, with around 1500 species (Frodin *et al.*, 2004). Brinjal is a warm season crop primarily cultivated in the country's tropical and sub-tropical regions. Though it is perennial in nature, it is often cultivated as an annual for its tender and immature fruits, to use as a vegetable. Furthermore, brinjal is a region-specific crop where consumer acceptance is based on their preference for color, shape, and taste suited for a specific locality (Chinthaguntiet *al.*, 2018).

Despite the high economic importance of this crop, brinjal is susceptible to many soil-borne diseases, pests and nematodes. Soil-borne diseases include bacterial wilt, verticillium wilt and fusarium wilt, and major pests such as shoot and fruit borer, ash weevil, mites, thrips, and aphids which results in heavy yield loss. The best way to control pests and diseases is by using resistant varieties. However, the availability of few resistant varieties and region-specific preferences by the consumer it is difficult to go for intensive breeding. Hence the

concept of grafting in brinjal with wild *Solanum* species has emerged as a new approach by grafting suitable scion to the resistant rootstock.

Grafting brinjal onto wild *Solanum* rootstock showed a significant yield increase and resistance to soil borne diseases. A number of wild *Solanum* species were recorded as resistant to diseases and nematodes. The wild species *S. villosum*, *S. torvum* and *S. sisymbriifolium* were identified as a possible source of resistance to soil borne pathogens and nematode (Zohura & Hoque, 2019; Perpetuo *et al.*, 2021). Followed by Dhivya *et al.* (2018) reported that *S. sisymbriifolium*, *S. torvum* and *Physalis peruviana* were resistant to root-knot nematode and *S. aethiopicum* and *S. incanum* were moderately resistant. However, their morphological similarities provide difficulties in their identification and potential utilization. Therefore, this paper provides a detailed description of these *Solanum* species along with coloured illustrations for easy identification and validation.

## MATERIALS AND METHODS

The present study was conducted in College Orchard, Department of Vegetable Science, HC & RI, TNAU, Coimbatore during 2021-22 to assess the morphological characters and distinguish the wild *Solanum* species. Five *Solanum* species viz., *Solanum capsicoides*, *Solanum chrysotrichum*, *Solanum sisymbriifolium*, *Solanum violaceum* and *Solanum torvum* were collected from different ecoregions and studied for morphological characterization. (Table 1). The plant species were initially identified and authenticated by the Botanical Survey of India (BSI), Southern Regional Centre, Coimbatore.

A detailed description of 23 morphological characters were studied, and the data were recorded by examining fresh samples for each species and certain characteristics such as hairiness of stem and leaves, using microscope. These species were evaluated for both qualitative and quantitative characteristics. The morphological characters have been made with reference to 'Descriptors for Eggplant' by the International Board for Plant Genetic Resources and Numerical taxonomic study of some *Solanum* L. species (Solanaceae) using vegetative and floral morphological by Bello *et al.* (2013) (Table 2).

## RESULTS AND DISCUSSION

Morphological characterization deals with the identification of plant species. Plant habit, stem structure, prickles, leaf orientation, size, hairs in abaxial & adaxial surface, flower colour, structure, fruit colour, size, and seed provided the essential source for plant identification. Twenty-three morphological characters were evaluated and studied for identification in this study. All the five species belongs to the subgenus *Leptostemonum* (Chairini *et al.*, 2012, Knapp *et al.*, 2019). Members of this group are identified by presence of sharp epidermal prickles, hence referred to as 'spiny solanums'. Flowers are pale mauve-violet arranged in a subumbellate or elongate inflorescence, with relatively long anthers and fruits are yellow-orange or red in colour (Kumar *et al.*, 2019). Under the subgenus *Leptostemonum* each species belongs to different section viz., *S. capsicoides* belongs to *Acanthophora*, *S. chrysotrichum* and *S. torvum* to section *Torva*, *S. sisymbriifolium* to section *Sisymbriifolium* and *S. violaceum* to section Old world Asia (Chairini *et al.*, 2012; Knapp *et al.*, 2019; Levin *et al.*, 2006; Wei *et al.*, 2019).

### **Qualitative characters**

Among the morphological characters studied, plant habit is a shrub for all five species where *S. capsicoides* is a herbaceous shrub with 0.5-1.0 m height and *S. chrysotrichum* a shrub or small tree with almost 4-5 m height. Stem color is recorded as green (*S. capsicoides*, *S. violaceum*), pubescent green (*S. chrysotrichum*, *S. torvum*) and viscid green (*S. sisymbriifolium*). The young stem and leaves are densely ferruginous in *S. chrysotrichum*, which is the key to identification of this species (Fig.2.D). Almost all the four species viz., *S. chrysotrichum*, *S. sisymbriifolium*, *S. violaceum* and *S. torvum* has scattered to dense stellate hairs in their stem, adaxial and abaxial surface of the leaves whereas *S. capsicoides* has simple glandular hairs in this region. Hence *S. capsicoides* is placed within the section *Acanthophora* due to the presence of simple hairs on the upper surface of the leaves (Levin *et al.*, 2005).

The presence of spines/prickles is a common character of the subgenus *Leptostemonum*. Some species have scattered prickles all over the stem and veins of leaves (*S. chrysotrichum*, *S. violaceum*) while *S. chrysotrichum* and *S. sisymbriifolium* are characterized by the presence of dense prickles on their surface (Fig. 1B, 2B, 3C, 4B, 5B). In *S. torvum* the prickles are present more in young than in old plants (Fig. 4B, C). The leaf blade lobing was recorded as intermediate (*S. capsicoides* and *S. violaceum*), strong (*S. chrysotrichum*), very strong (*S. sisymbriifolium*) and weak (*S. torvum*) while leaf apex was recorded as intermediate (*S. capsicoides*), acute (*S. chrysotrichum*, *S. torvum*), very acute (*S. sisymbriifolium*) and very obtuse (*S. violaceum*).

In the genus *Solanum*, flowers are usually white, blue, or violet and pentamerous with equal stamens. The stamens dehisce by terminal pores and lack a terminal appendage (Kumar et al., 2019; D'Arcy et al., 1992). In association with the earlier studies, flowers of all five species are pentamerous in nature with bright yellow anthers and exerted stigma. Corolla colour was recorded as white for all except *S. violaceum* being pale mauve-violet. The surface of *S. chrysotrichum* and *S. torvum* were recorded as unarmed in calyx, pedicel, and peduncle, while the other three species are completely armed in nature. Fruits of all five species are globose berry, while mature fruit colour ranges from green to yellow (*S. chrysotrichum*, *S. torvum*), scarlet orange (*S. capsicoides*), bright red (*S. sisymbriifolium*) to orange red (*S. violaceum*). Seeds are orbicular or sub orbicular in shape and pale brown in colour for all species except *S. capsicoides* where the seeds are flattened, winged, and considerably round with straw colour (Fig. 1F).

#### **Quantitative data**

Quantitative characters like plant height, leaf length, leaf width, number of flowers per cluster, and fruit diameter were observed for all the genotypes (Table 3).

#### **KEY TO THE SPECIES**

- |   |                                  |
|---|----------------------------------|
| 1. Stems erect to prostrate; prickles straight; berries orange red when ripe; seeds with a wing like hyaline margin         | <b><i>S. capsicoides</i></b>     |
| 2. Young stems and leaves with ferruginous pubescent; trichomes on the inflorescences; prickles straight to curved slightly | <b><i>S. chrysotrichum</i></b>   |
| 3. Corolla white to purple, flowering calyx prickly; berries less than 1.5 cm across  | <b><i>S. sisymbriifolium</i></b> |
| 4. Perennial or annual, prickles curved; corolla violet with white midrib spreading   | <b><i>S. violaceum</i></b>       |
| 5. Pubescent green stem; lamina without prickles; flowers white; slightly curved prickles                                   | <b><i>S. torvum</i></b>          |

#### **CONCLUSION**

Given the size and importance of morphological characterization, five *Solanum* species belonging to subgenus *Leptostenomum* was studied in a broad manner. This subgenus includes a number of economically important species which shows resistance to soil borne diseases and nematode. As brinjal is a region specific crop, it would be laborious to use resistant lines in breeding for all consumer preferred varietal types. Hence, using a wild *Solanum* species with resistance to diseases as rootstock and the cultivable type as scion is highly preferable. Thereby, this study will be a supportive database for identifying the distinctiveness, uniformity and stability (DUS) of each species and their utilization in future work.

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#### Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

#### Consent for publication

All the authors agreed to publish the content.

#### Competing interests

There were no conflict of interest in the publication of this content

#### Author contributions

Research grant-LP, GSV, Idea conceptualization-LP, Experiments-GSV, Guidance -LP, TS, TR, AS, PJ, Writing original draft - GSV, Writing- reviewing & editing -GSV, LP, TS, TR, AS, PJ.

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**Table 1. Collection details of *Solanum* species from Natural Populations**

Subgenus	Section / Clade	Species name	Common name	Area of collection
<b><i>Leptostemonum</i></b>	<i>Acanthophora</i>	<i>Solanum capsicoides</i> All.	Cockroach berry	Ernakulam, Kerala
	<i>Torva</i>	<i>Solanum chrysotrichum</i> Schltld.	Giant devil's-fig	Yercaud, Tamilnadu
	<i>Sisymbriifolium</i>	<i>Solanum sisymbriifolium</i> Lam.	Sticky nightshade	Ooty, Tamilnadu
	Old World Tropical Asia	<i>Solanum violaceum</i> Ortega.		Yercaud, Tamilnadu
	<i>Torva</i>	<i>Solanum torvum</i> Sw.	Turkey berry	Coimbatore, Tamilnadu

**Table 3. Quantitative characters of wild *Solanum* species studied**

Characters	<i>S. capsicoides</i>	<i>S. chrysotrichum</i>	<i>S. sisymbriifolium</i>	<i>S. violaceum</i>	<i>S. torvum</i>
1. Plant height	0.5-1.0 m	4-5 m	1-2 m	0.5-2 m	1.5-3 m
2. Leaf length	5-15 cm	5-25 cm	10-20 cm	5-15 cm	8-20 cm
3. Leaf width	4-10 cm	5-15 cm	5-10 cm	5-10 cm	6-15 cm
4. No. of flowers per inflorescence	1-6	5-20	6-16	6-14	10-30
5. Fruit diameter(cm)	2 – 3 cm	1-2 cm	0.5- 1.5 cm	0.4-1.0 cm	1- 2 cm



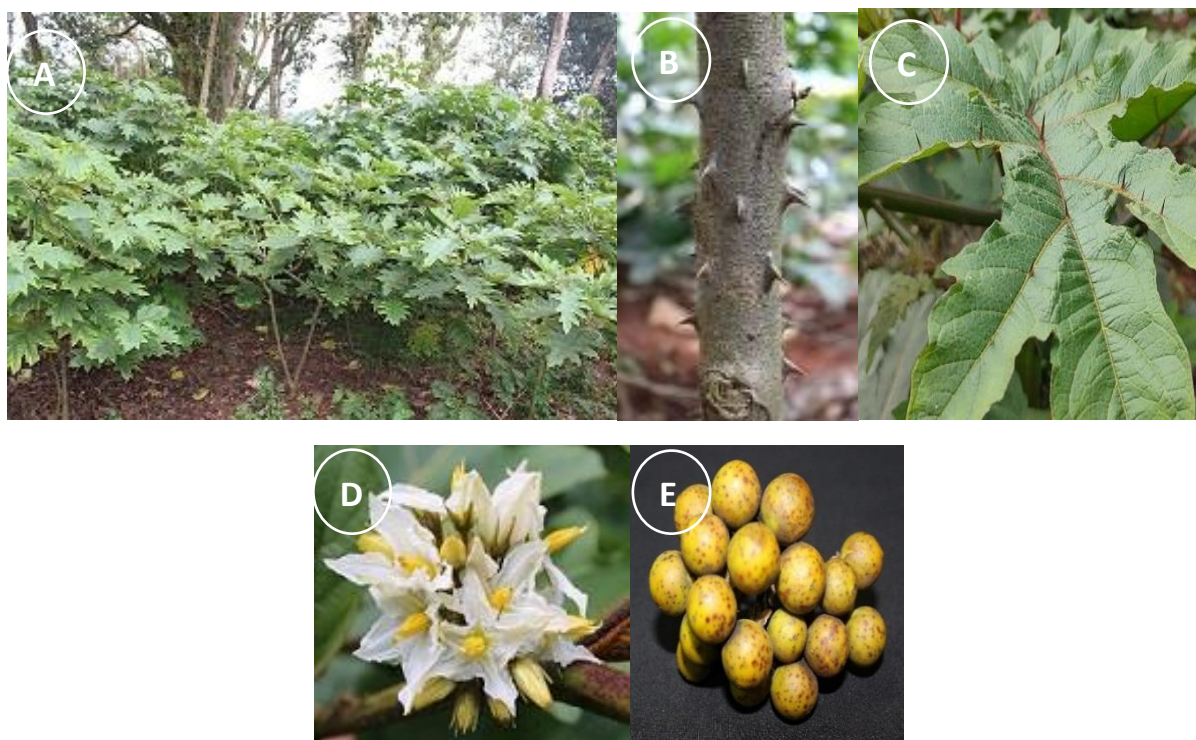
**Table 2. Summary of the Qualitative morphological characters and character states of wild *Solanum* species studied**

Characters and Descriptors	<i>S. capsicoides</i>	<i>S. chrysotrichum</i>	<i>S. sisymbriifolium</i>	<i>S. violaceum</i>	<i>S. torvum</i>
1. Habit ( Herb/Shrub/ tree )	Herbaceous shrub	Shrub or Small tree	Shrub	Shrub	Shrub
2. Stem colour (Green / Pubescent/Villous )	Green	Pubescent green	Viscid green	Bright green	Pubescent green
3. Stem Surface hair ( Glabrous/Sparsely pubescent/ Villous/Stellate-tomentose / Sellate )	Simple glandular hairs	Stellate (Ferruginous)	Stellate	Stellate	Stellate
4. Stem prickles (Unarmed / Armed)	Dense	Sparse	Dense	Sparse	Sparse
5. Leaf blade lobing (Very weak, Weak, Intermediate, Strong, Very strong)	Intermediate	Strong	Very strong	Intermediate	Weak
6. Leaf prickles (Unarmed / Armed)	Armed - Scattered to many prickles on veins	Armed - Scattered prickles on veins	Armed - Dense prickles on whole leaf	Armed - Sparse prickles on main veins	Armed Prickles – young plant Smooth – old plant
7. Leaf apex (Very acute, acute, intermediate, obtuse, very obtuse)	Intermediate	Acute	Very acute	Very obtuse	Acute
8. Leaf adaxial surface (Glabrous/Sparsely pubescent /Villous/Stellate-tomentose/ Sellate )	Simple glandular hairs	Stellate	Stellate	Stellate	Stellate
9. Leaf abaxial surface ( Glabrous/Sparsely pubescent /Villous/Stellate-tomentose/ Sellate )	Simple glandular hairs	Stellate	Stellate	Stellate	Stellate
10. Corolla colour (White /White with black midrib outside /Pale mauve-violet)	White	Cream white	White	Pale mauve- violet	Cream white
11. Anther colour (Yellow/ Blue)	Yellow	Yellow	Yellow	Yellow	Yellow
12. Calyx surface (Unarmed / Armed)	Armed	Unarmed	Armed	Armed	Unarmed
13. Pedicel surface(Unarmed / Armed)	Armed	Unarmed	Armed	Armed	Unarmed
14. Peduncle surface(Unarmed / Armed)	Armed	Unarmed	Armed	Armed	Unarmed
15. Fruit shape (Globose /Spherical )	Globose berry	Globose berry	Globose berry	Globose berry	Globose berry
16. Immature Fruit colour ( Green /White mottled with green veins / Yellow)	Green	Green	Green	Green	Green
17. Mature Fruit colour (Yellow –Orange /Red /Black/Brown)	Scarlet orange	Yellow	Bright red	Orange red	Yellow





**Figure 1.** *Solanum capsicoides* All: A. Habit, B. Spiny stem, C. Flower bud, D. Flower, E. Fruits, F. Seed



**Figure 2.** *Solanum chrysotrichum* Schtdl : A. Habit, B. Stem, C. Abaxial view of leaf, D. Inflorescence, E. Fruits





Figure 3. *Solanum sisymbriifolium* Lam: A. Habit, B. Leaf, C. Stem, D. Flower, E. Fruit

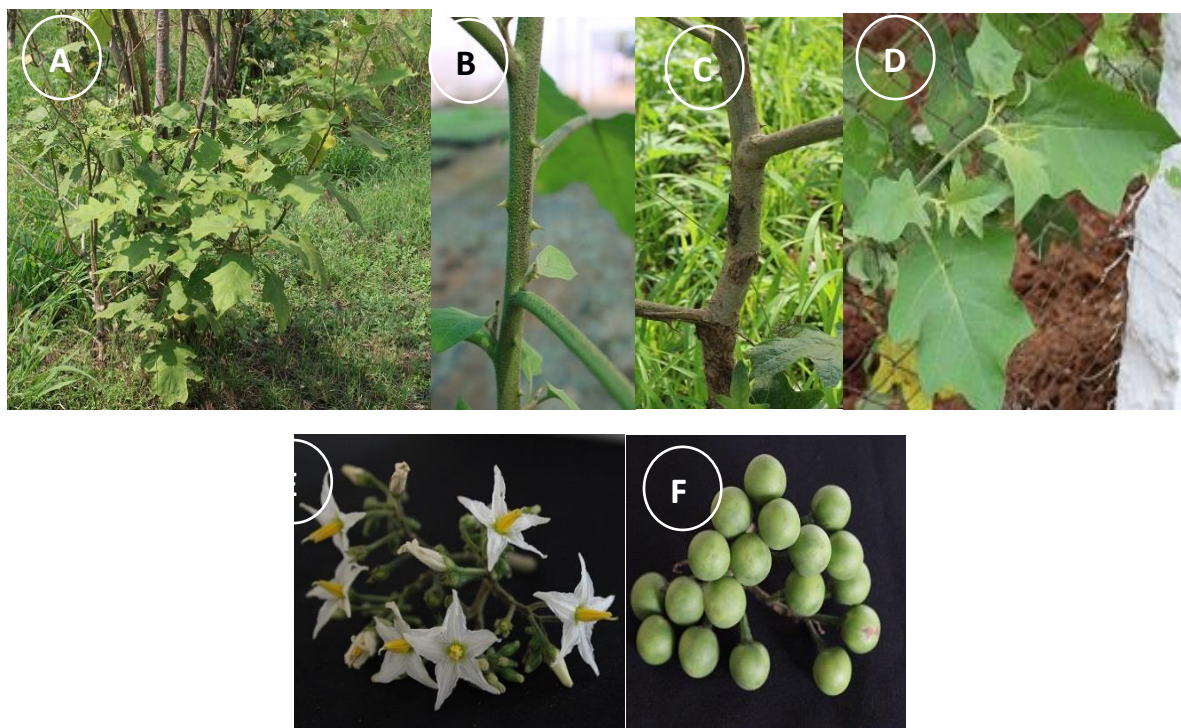
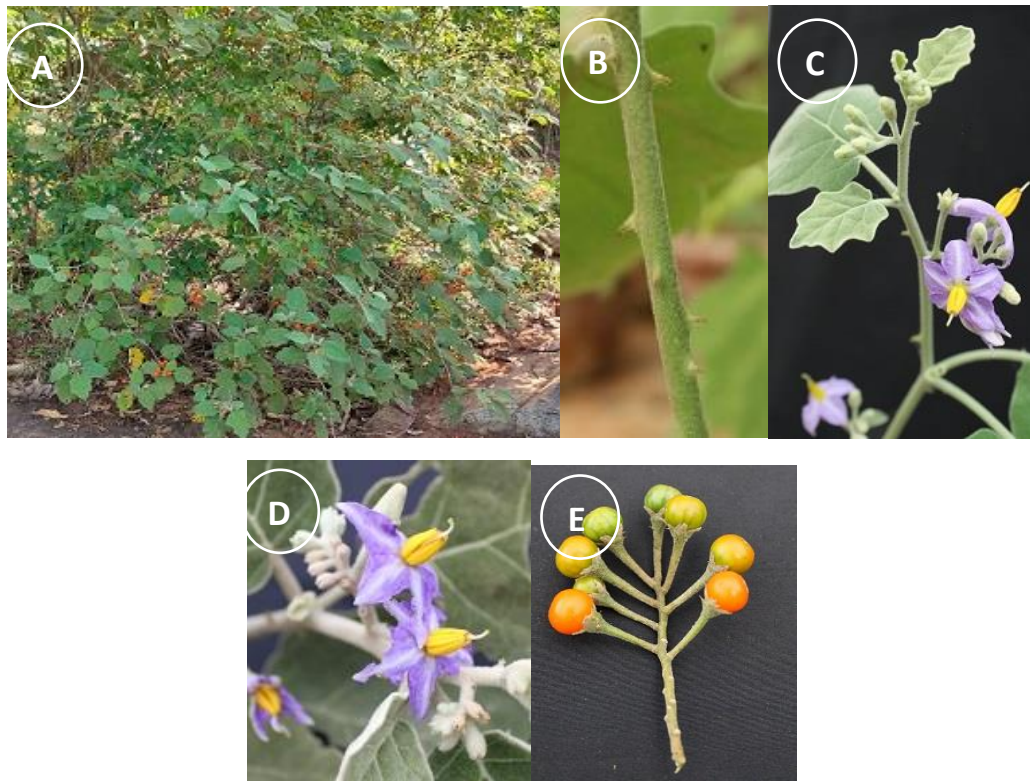


Figure 4. *Solanum torvum* Sw: A. Habit, B & C. Stem of young and old plant, D. Leaf, E. Inflorescence, F. Fruit





**Figure 5.** *Solanum violaceum* Ortega: A. Habit, B. Stem, C. Shoot, D. Inflorescence, E. Fruits