



Collection and Evaluation of Indigenous and Wild *Solanum* spp. Germplasm for Root Stock Suitability under Abiotic Stress Conditions

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ABSTRACT

A plant exploration survey was conducted in July 2023, during which the indigenous brinjal cultivar *Pandiri Vankaya* was collected from farmers in Rayachoti village, Adilabad district. Additionally, wild species including *Solanum viarum* (nightshade/soda apple) and *Solanum torvum* (turkey berry) were collected from the Mavala forest range of Adilabad. Alongside these indigenous and wild collections, the cultivated purple long brinjal cultivar *Bhagyamati* and the F1 hybrid *Vipra* were included in the study. Seedlings of all genotypes were raised in pro trays to assess germination percentage, days to reach grafting stage (i.e., attainment of the fifth true leaf), and Seedling Vigour Index I (SVI-I). The seedlings were further evaluated under controlled greenhouse conditions for tolerance to abiotic stresses, including waterlogging, salinity, and drought, with the objective of identifying potential alternative rootstocks to *S. torvum*. Among the evaluated genotypes, *Pandiri Vankaya* exhibited the highest germination rate (85.41%) and SVI-I value (2566.68), reaching the fifth true leaf stage in 43.40 day, surpassing *S. torvum* and other cultivars. Under salinity and drought stress conditions, *S. torvum* demonstrated the highest tolerance, followed by *Pandiri Vankaya* and *S. viarum*. In contrast, under waterlogging conditions, *Pandiri Vankaya* showed the highest tolerance, followed by *S. viarum*.

Keywords: Vegetable grafting, rootstock evaluation, waterlogging, drought, salinity stress

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1. Introduction

Brinjal (*Solanum melongena* L.) is a warm-season vegetable extensively cultivated in tropical and subtropical regions of India, (Sadanand Kumbar et al., 2021) contributes 22.72% of global brinjal production, with 12.78 million tonnes grown on 750,000 hectares (FAOSTAT, 2022). In 2022–2023, Telangana alone produced 127,000 tonnes from 2,830 hectares (Anonymous, 2024). Brinjal ranks fifth in economic importance among Solanaceae crops, following potato, tomato, pepper, and tobacco (Taher et al., 2017). The genus *Solanum* in India comprises 22 species, including five closely related diploid species (*S. melongena*, *S. coagulans*, *S. xanthocarpum*, *S. indicum*, and *S. maccanii*) with $2n = 2x = 24$ chromosomes (Singh et al., 2015). However, brinjal productivity is limited by both biotic and abiotic stresses such as bacterial wilt, nematode infestation, salinity, drought, and waterlogging. Vegetable grafting has emerged as an effective strategy to enhance tolerance to these stresses by improving root system performance and resource use efficiency. The use of wild *Solanum* species as rootstocks has gained momentum, particularly *S. torvum* (resistant to bacterial wilt and nematodes) and *S. viarum* (resistant to shoot and fruit borers) (Karthiga et al., 2023; Schwarz et al., 2010). Despite these advancements, the propagation and performance of rootstocks still face challenges due to compatibility, poor germination, or limited environmental adaptability. In this context, underutilized indigenous cultivars with superior germination and adaptability, such as *Pandiri Vankaya*, offer a valuable alternative for enhancing abiotic stress resilience in brinjal grafting programs.

Rootstock propagation typically occurs at the two-true-leaf stage to ensure compatibility in stem diameter between the rootstock and scion. Rootstock selection is critical and is based on compatibility, disease resistance, and stress tolerance (Malhotra et al. 2017; Yun et al. 2023). However, successful rootstock production remains challenging due to compatibility issues (Edelstein et al. 2015; Zhen et al. 2022). While cultivated brinjal exhibits substantial genetic diversity, wild and indigenous species remain underutilized. For example, *S. viarum*, known for its fruit resembling miniature watermelons, is resistant to shoot and fruit borers. *S. torvum*, though widely adopted for its tolerance to multiple stresses, suffers from poor germination due to seed dormancy—a challenge that can be addressed through seed soaking, scarification, heat treatment, or application of growth regulators (Ranil et al., 2015). Indigenous brinjal cultivars, often grown in backyard gardens, exhibit high germination rates, extended life cycles (4–5 years), and diverse agronomic traits, making them ideal candidates for rootstock evaluation.

Rootstocks enhance plant resilience by improving water and nutrient uptake and offering resistance to soil-borne pathogens (Ashok kumar et al., 2017; Edelstein et al., 2017; Chandanshive et al., 2023) and also abiotic stresses such as salinity, flooding, drought (Li et al., 2016; Liang et al., 2022; Wakchaure et al., 2025). In tomato cultivation, *S. melongena* has been used to combat bacterial wilt and flooding. *S. torvum*, a wild relative, is widely adopted for resistance to root-knot nematodes and bacterial wilt. The Asian Vegetable Research and Development Center (AVRDC) recommends *S. melongena* lines VI046103 (EG195), VI045276 (EG203), and tomato rootstock VI043614 (Hawaii 7996) for cultivation in abiotic stress-prone regions (Pradeep Kumar et al., 2018).

Drought stress adversely impacts plant physiological and metabolic functions. Grafting has been shown to enhance water-use efficiency and improve yield. Holbrook et al. (2002) reported that root-derived chemical signals regulate stomatal closure under water deficit

conditions. Similarly, grafting mitigates the effects of salinity by enhancing photosynthetic efficiency and reducing toxic ion accumulation (Colla et al., 2010; Pradeep Kumar et al., 2018). Physiological response of waterlogging is variable for different crops causes reduced nutrients intake, stunted growth and low yield (Kim et al., 2018). The selection of tolerant rootstocks or the use of resilient germplasm is essential for managing such stresses (Cattivelli et al., 2008; Harsha et al., 2024). The primary objective of this study was to evaluate the rootstock potential of indigenous and wild brinjal germplasm under various abiotic stress conditions.

2. Materials and Methods

The experiment was conducted at the Horticultural Research Station, Adilabad, in October 2023. In this study, a selected set of five indigenous and wild brinjal genotypes, including one F1 hybrid, was evaluated for their suitability as rootstocks under abiotic stress conditions, specifically waterlogging, drought, and salinity. Details of the wild and indigenous brinjal accessions used in the study are presented in Table 1.

Table 1: Wild and the Indigenous brinjal germplasm used the abiotic stress tolerance study.

Germplasm	Source of collection	Special Characteristics
<i>Solanum torvum</i>	Mavala, Adilabad district	Commonly found in backyards and along roadsides, <i>S. torvum</i> is recognized for its small, clustered fruits used in curries and for drying. It is widely utilized as a rootstock due to its natural resistance to Fusarium wilt and bacterial wilt.
<i>Solanum viarum</i>	Mavala, Adilabad district	Commonly known as tropical soda apple, this bushy, herbaceous perennial reaches a height of 3–6 feet. It features deeply lobed, hairy leaves and is heavily armed with white to yellowish thorns. The plant bears white flowers with yellow stamens and globular fruits that turn yellow upon ripening (Anonymous, 2023).
<i>Solanum melongena</i> cv. pandiri vankaya	Rayachoti, Adilabad district	A perennial cultivar with light green, elongated fruits. It is locally appreciated for its good taste and is notably less susceptible to pests and diseases.
<i>Solanum melongena</i> cv Bhagyamati	Vegetable Research Station, Rajendranagar	Produces oblong, deep purple fruits. It is a widely cultivated commercial variety.
<i>Solanum melongena</i> F ₁ hybrid Vipra	Seedsmen Association, Hyderabad	A vigorous, erect, and spineless hybrid reaching a height of 120–140 cm, characterized by oblong leaves and solitary, whitish-purple flowers.

2.1 Abiotic Stress Treatment

The experiment was conducted using a completely randomized design (CRD) with four replications. Seedlings from the selected brinjal germplasm were sown in protrays filled with a cocopeat and vermicompost mixture in a 3:1 ratio. After germination, the trays were maintained under a shade net to support seedling development. Approximately 45 days after sowing, the seedlings were transplanted into pots. Each replication consisted of 20 pots, with each pot having a capacity of 1.5 liters. The seedlings were irrigated immediately after transplantation.

To evaluate drought tolerance, water stress was induced by withholding irrigation, a commonly used method to simulate drought conditions. In eggplant, drought stress is typically applied at the five true-leaf stage in greenhouse trials or five weeks after transplantation in field trials (Saavedra et al., 2023). In this study, irrigation was withheld for 11 consecutive days under greenhouse conditions. Waterlogging stress was imposed by transplanting the seedlings into pots without drainage holes, ensuring prolonged exposure to saturated soil conditions. Seedlings raised in protrays from five different brinjal germplasm were evaluated for germination percentage, seedling length, Seedling Vigour Index-I (SVI-I), and the number of days required to reach grafting size (i.e., attainment of the fifth true leaf). Screening results for drought, salinity, and waterlogging tolerance are presented in Tables 2 and 3.

2.2 Germination and Seedling Measurements

Germination Percentage

Germination percentage was calculated based on the number of normal seedlings recorded on the 14th day after sowing.

$$\text{Germination \%} = (\text{Total seeds sown} / \text{Number of normal seedlings}) \times 100$$

Seedling Length (cm)

Seedling length was measured as the sum of shoot length and root length (both in centimeters).

Seedling Vigour Index (SVI)

The Seedling Vigour Index was calculated following the method described by Abdul-Baki and Anderson (1973) and Sunil Kumar et al. (2020). It is expressed as a whole number and calculated using the formula:

$$\text{SVI} = \text{Germination (\%)} \times \text{Seedling length (cm)}$$

2.3 Stress Tolerance Scoring

Waterlogging tolerance was assessed using a visual rating scale adapted from Kim et al. (2018), where a score of 1 indicated no plant damage and healthy plants; 2 represented initial signs of wilting and curling; 3 corresponded to most leaves wilting and drooping; 4 indicated all leaves were wilted with many turning brown and crispy; and 5 denoted the death of the growing point.

Drought tolerance was evaluated based on leaf drying symptoms at the vegetative stage, using the Standard Evaluation System (SES) scale described by Swain et al. (2019). Scores ranged from 0 for no symptoms, 1 for slight tip drying, 3 when tip drying extended up to one-fourth of the leaf area, 5 when one-fourth to one-half of the leaves were dried, 7 when more than two-thirds of leaves were fully dried, and 9 indicating all plants were dead.

Salinity tolerance was scored according to the modified SES scale from Duc Le et al. (2021), based on leaf injury symptoms: a score of 1 represented normal growth with no leaf symptoms; 3 indicated near normal growth but with whitish and rolled leaf tips or a few affected leaves; 5 corresponded to severely retarded growth with most leaves rolled and only a few elongating; 7 reflected complete cessation of growth, most leaves dry, and some plants dying; and 9 denoted almost all plants dead or dying.

2.4 Statistical Analysis

The experiment was laid out using a completely randomized design (CRBD) with four replications to ensure the reliability and accuracy of the results. This design allowed for the random allocation of treatments to experimental units, thereby minimizing the effects of uncontrolled variability. Data collected on various quantitative parameters were subjected to statistical analysis using the GRAPES online statistical software, specifically the Completely Randomized Design (CRD) module developed by Gopinath et al. (2020). Analysis of variance (ANOVA) was performed to test the significance of treatment effects. When the ANOVA results indicated statistically significant differences among treatments at the 5% significance level ($p < 0.05$), the means were further compared using Tukey's Honest Significant Difference (HSD) test. This post-hoc test allowed for multiple pairwise comparisons to identify which treatment means differed significantly, ensuring robust and reliable interpretation of the experimental outcomes.

3. Results and Discussion

The results of various parameters, including seed germination percentage, days taken to reach grafting size (5th true leaf stage), seedling length at 30 days after sowing (DAS), and Seedling Vigour Index-I (SVI-I) for different brinjal germplasm, are presented in Table 2.

Table 2: Seed germination percentage, days to grafting size, seedling length, and seedling vigour index (SVI-I) of brinjal germplasm

Germplasm	Germination %	Days to 5th true leaf stage	Seedling length (cm) at 30 DAS	SVI-I
<i>S. torvum</i>	18.47 d	63.07 a	28.85 ab	532.79 d
<i>S. viarum</i>	63.21 b	45.40 c	19.35 d	1222.68 b
Indigenous collection	85.41 a	43.40 d	30.05 a	2566.68 a
Bhagyamati	27.35 c	46.70 bc	27.12 b	741.85 c
Vipra	12.71 e	48.35 b	24.02 c	305.57 e
SE (m) $\pm$	0.31	0.43	0.66	30.73
CD at 5%	0.66	0.92	1.40	65.48
CV (%)	1.49	1.74	5.11	5.73

Values followed by different letters within a column are significantly different according to Tukey's HSD test at $p \leq 0.05$.

3.1 Germination percentage

Germination, the initial stage of plant growth marked by seedling emergence, is a critical factor for successful crop establishment. The germplasm showed significant variation in germination percentage. The indigenous collection recorded the highest germination rate at 85.41%, followed by *S. viarum* at 63.21%, Bhagyamati at 27.35%, and *S. torvum* at 18.47%. The lowest germination percentage was observed in Vipra (12.71%). These differences may be attributed to the varying abilities of the plants to supply assimilates required for synthesizing storage compounds during germination (Dornbos and McDonald, 1986). Additionally, physiological damage to seeds can impair mobilization efficiency, resulting in poor root and shoot development (McDonald and Nelson, 1986; Coolbear, 1995; Powell, 2006).

3.2 Days to 5th true leaf stage

Attainment of the fifth true leaf stage marks the optimal point for grafting operations. *Pandiri Vankaya* reached this stage earlier than the other entries (43.40 days), indicating its potential for rapid nursery propagation. Conversely, *S. torvum* required over 63 days, consistent with prior reports of its slow and erratic germination due to seed dormancy (Ranil et al., 2015). These findings suggest that indigenous cultivars can expedite grafting operations and reduce nursery time.

3.3 Seedling length (cm) at 30 DAS

Seedling length showed considerable variation across the germplasm tested. The indigenous collection had the longest seedlings (30.05 cm), whereas *S. viarum* produced the shortest seedlings (19.35 cm). *S. torvum* seedlings measured 28.85 cm, statistically comparable to Bhagyamati (27.12 cm), but significantly longer than Vipra (24.02 cm).

3.4 Seedling Vigour Index (SVI-I)

SVI-I integrates germination and seedling growth to estimate overall seedling performance. The superior SVI-I observed in *Pandiri Vankaya* (2566.68) highlights its potential for vigorous growth and rapid establishment. *S. torvum*, while traditionally used as a rootstock, showed a relatively lower SVI-I (532.79), reflecting its limitations in early-stage performance despite its stress tolerance traits.

3.5 Screening for Abiotic Stress Tolerance

The evaluation of waterlogging, drought, and salinity tolerance among different brinjal germplasm revealed significant variation in stress adaptability (Table 3).

Table 3: Screening for abiotic stress tolerance of brinjal germplasm.

Germplasm	Water logging	Drought	Salinity	Cumulative score
<i>Solanum torvum</i>	4.0 a	1.5 b	1.2 b	6.7 a
<i>Solanum viarum</i>	2.7ab	4.5 ab	2.0 ab	9.2 a
Indigenous collection	1.0 c	4.0 ab	2.5 ab	7.5 a
Bhagyamati	2.2 bc	5.0 ab	2.7 ab	10.0 a
Vipra	2.7 ab	5.5 a	3.2 a	11.5 a
SE (m) ±	0.37	0.85	0.35	1.09
CD at 5%	0.79	1.81	0.74	2.32
CV %	29.08	41.29	29.58	24.25

Values followed by different letters within a column are significantly different according to Tukey's HSD test at $p \leq 0.05$.

3.5 Waterlogging

Waterlogging tolerance was highest in the indigenous collection, which recorded the lowest score of 1.0, indicating superior resilience to excess water conditions. Bhagyamati followed with a score of 2.2, which was statistically similar to *Solanum viarum* and Vipra, both scoring 2.7. *Solanum torvum* exhibited the least tolerance, with the highest score of 4.0, suggesting sensitivity to waterlogged conditions.

3.6 Drought

In terms of drought tolerance, *Solanum torvum* demonstrated the greatest adaptability, achieving the lowest score of 1.5. The indigenous collection (4.0), *S. viarum* (4.5), and Bhagyamati (5.0) exhibited moderate tolerance and were statistically comparable. Vipra was the least tolerant, with a score of 5.5, indicating greater susceptibility to water deficit stress.

3.7 Salinity

For salinity tolerance, *S. torvum* again ranked highest with a score of 1.2, reflecting its ability to maintain growth and reduce leaf injury under saline conditions. *S. viarum* (2.0) and the indigenous collection (2.5) showed moderate and statistically similar tolerance levels, whereas Bhagyamati (2.7) and Vipra (3.2) were comparatively more sensitive to salt stress.

3.8 Cumulative score

Considering the cumulative stress tolerance across all three abiotic stresses, *S. torvum* had the lowest total score of 6.7, making it the most adaptable germplasm overall. The indigenous collection followed closely with a cumulative score of 7.5, indicating balanced tolerance to multiple stresses. In contrast, *S. viarum* (9.2), Bhagyamati (10.0), and Vipra (11.5) showed progressively higher scores, reflecting lower overall adaptability under combined stress conditions. Significant genotypic variation was recorded in response to drought, salinity, and waterlogging stresses. *S. torvum* consistently exhibited the lowest scores under drought and

salinity, confirming its resilience as a stress-tolerant rootstock (Colla et al., 2010; Pradeep Kumar et al., 2018). However, its poor waterlogging tolerance (score: 4.0) limits its adaptability in high rainfall regions. In contrast, *Pandiri Vankaya* scored 1.0 under waterlogging stress, indicating exceptional adaptability to saturated soil conditions. These findings are supported by previous studies on the genetic basis of waterlogging tolerance in eggplant germplasm (Lin et al., 2004). The cumulative stress score reveals that although *S. torvum* is superior in drought and salinity tolerance, the indigenous *Pandiri Vankaya* is a strong candidate for integrated stress management, especially in regions prone to waterlogging. The performance of *S. viarum* also suggests intermediate utility for moderate stress environments.

4. Conclusions

The study highlights the potential of indigenous and wild *Solanum* germplasm as rootstocks for brinjal under abiotic stress. While *S. torvum* performs well in drought and salinity, its poor early growth and waterlogging intolerance limit its use. *Pandiri Vankaya* shows superior vigor, establishment, and waterlogging tolerance, making it ideal for rainfed and flood-prone areas. The findings stress the importance of indigenous germplasm in climate-resilient breeding. Further research should assess *Pandiri Vankaya*'s graft compatibility, performance, and disease resistance for commercial grafting.

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