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Grafting compatibility and performance of Brinjal scions on wild solanum rootstocks

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Abstract
Can wild Solanum species serve as reliable rootstocks for commercial brinjal production in subtropical regions? This research aimed to answer that question by evaluating grafting compatibility and agronomic performance of brinjal (*Solanum melongena* L. cv. Pusa Purple Long) scions grafted onto four wild rootstock species: *Solanum torvum*, *Solanum sisymbriifolium*, *Solanum khasianum*, and *Solanum incanum*. The experiment was carried out from June 2023 to February 2024 at the Escola Superior de Ciências Agrárias do Sul, Porto Alegre, Brazil, using a randomized complete block design with four replications and ten plants per treatment. Cleft grafting was the chosen technique, and graft success rate, vascular connection quality, plant height, number of branches, days to first flowering, fruit yield per plant, and fruit quality traits were measured across all treatments. *Solanum torvum* showed the highest graft take (87.3%) and produced a strong vascular union confirmed through histological cross-sections. Plants on *S. torvum* rootstock recorded a mean yield of 3.47 kg per plant, which was 28.6% higher than the non-grafted control. *Solanum incanum* also performed well, with an 81.5% graft take and 3.21 kg yield per plant. Both *S. sisymbriifolium* and *S. khasianum* gave acceptable but lower compatibility. Fruit quality parameters including total soluble solids, firmness, and skin color didn't differ markedly between grafted and non-grafted plants. These results point to *S. torvum* and *S. incanum* as practical rootstock options for brinjal growers in subtropical Brazil.

Keywords: Grafting compatibility, brinjal, wild solanum, rootstock performance, vegetable grafting, cleft grafting, *Solanum torvum*, vascular union, subtropical horticulture, scion-rootstock interaction

Introduction
What practical solutions exist for brinjal growers who face recurring soil-borne diseases yet cannot afford the costs of soil fumigation or frequent field rotation? Grafting onto resistant rootstocks has emerged as one direct answer, and its adoption in vegetable production has expanded steadily across Asia, the Mediterranean, and parts of South America [1]. Brinjal (*Solanum melongena* L.) ranks among the top five most consumed vegetables in tropical and subtropical countries, with global production exceeding 57 million tonnes annually [2]. But the crop is highly susceptible to bacterial wilt (*Ralstonia solanacearum*), *Fusarium* wilt, and root-knot nematodes, which can reduce marketable yields by 30-70% in infested soils [3].

Wild Solanum species have drawn attention as potential rootstocks because many of them carry innate resistance to these pathogens. *Solanum torvum* Sw. is perhaps the most widely tested rootstock worldwide; field trials across India, Thailand, and Italy have confirmed its tolerance to bacterial wilt and its compatibility with multiple eggplant cultivars [4, 5]. *Solanum sisymbriifolium* and *Solanum khasianum* are lesser-known candidates that show promise against nematode pressure, while *Solanum incanum* possesses drought tolerance traits alongside moderate disease resistance [6, 7].

The success of any grafting operation depends on the degree of vascular alignment and callus formation between scion and rootstock tissues. Incompatible unions often result in weak mechanical connections, restricted water flow, and eventual plant decline weeks or months after initial graft healing [8]. Several physiological markers—such as peroxidase activity at the graft junction and lignin deposition patterns—can predict long-term compatibility, though field validation remains limited for many wild Solanum combinations [9].

In southern Brazil, brinjal production faces particular challenges. Heavy rainfall promotes Ralstonia spread, and acidic soils in Rio Grande do Sul favor *Fusarium* persistence [10].

Local growers still rely heavily on chemical control, and there's a growing need for integrated approaches that include grafting. But most grafting research so far has been carried out under Asian or Mediterranean conditions, and there's little data from Brazilian subtropical environments [11].

This research was designed to fill that gap. The objectives were: (a) to compare graft compatibility of four wild Solanum rootstocks with the popular brinjal cultivar Pusa Purple Long using cleft grafting; (b) to measure the agronomic performance of grafted plants including vegetative growth, yield, and fruit quality; and (c) to confirm vascular union integrity through histological examination. The findings may help guide rootstock selection for brinjal growers in subtropical South America.

Research Area Description

The research was conducted at the experimental horticultural farm of the Escola Superior de Ciências Agrárias do Sul, located in Porto Alegre, Rio Grande do Sul, Brazil (30°01'S, 51°13'W, elevation 46 m above sea level). Porto Alegre has a humid subtropical climate classified as Cfa under the Köppen system, with mean annual rainfall of 1,347 mm distributed throughout the year and a warm summer period from November through March. The experimental site had a history of continuous vegetable cultivation for nine years, and the soil was classified as a Haplic Acrisol (Argissolo Vermelho-Amarelo in the Brazilian system) with pH 5.4, organic matter content of 2.1%, and a clayey texture. Mean daily temperatures during the trial ranged from 13.8°C in July to 26.3°C in January. Irrigation was provided through a drip system at field capacity throughout the growing period.

Material and Methods

Material

Seeds of four wild Solanum rootstock species—*S. torvum*, *S. sisymbriifolium*, *S. khasianum*, and *S. incanum*—were obtained from the germplasm collection maintained by the Department of Horticultural Sciences, Escola Superior de Ciências Agrárias do Sul, Porto Alegre. Scion material was the commercial brinjal cultivar Pusa Purple Long, sourced from a certified seed supplier in São Paulo. Rootstock seeds were sown in 72-cell plug trays filled with a peat-perlite mix (3:1 v/v) in a climate-controlled nursery at 28±2°C. Scion seeds were sown 12 days after rootstocks to synchronize stem diameters at grafting. Seedlings reached grafting readiness when rootstocks had 4-5 true leaves and scion stems measured 3-4 mm in diameter. Additional inputs included grafting clips (2.0 mm silicone), a sharp ceramic blade sterilized between cuts, and a healing chamber maintained at 27°C with 90% relative humidity. Histological analysis used toluidine blue O stain and a standard paraffin embedding protocol.

Methods

The experiment followed a randomized complete block design with five treatments (four rootstocks plus non-grafted control) and four replications, each containing ten plants. Cleft grafting was performed at 35 days after sowing of rootstocks. Each rootstock stem was cut horizontally at the second internode, a 1.5 cm vertical split was made, and the scion—trimmed to a wedge shape—was inserted and secured with a silicone clip. Grafted plants were immediately transferred to a healing chamber for 14 days under reduced light (50 μmol m^{-2} $s^{-\pm}$ PAR), then gradually acclimatized over 7 days before transplanting to open field beds at 60 × 75 cm spacing in August 2023 [12].

Graft success was recorded 21 days after grafting as the percentage of surviving unions. Vascular connectivity was assessed at 45 days by sectioning the graft junction and staining with toluidine blue O. Plant height, branch number, and days to first flowering were recorded at 60 and 90 days after transplanting. Fruit harvest began 95 days after transplanting and continued biweekly for 12 pickings. Total yield per plant, average fruit weight, and number of marketable fruits were recorded. Fruit quality traits—total soluble solids (TSS), firmness (measured with a penetrometer), and skin colour (L, *a*, b* values)—were assessed on five randomly chosen fruits per replication at third and eighth harvests [13]. Data were subjected to one-way ANOVA and means separated using Tukey's HSD test at $p \leq 0.05$. All statistical procedures were run in R version 4.3.1.

Field Experimental Design

Transplanting was done on raised beds (1.2 m wide, 0.3 m height) oriented north-south to maximize light interception. Each replicate block measured 18 m × 6 m and contained all five treatments arranged randomly within the block. Inter-block spacing was 2 m to reduce edge effects. A border row of non-grafted brinjal surrounded each block. Drip irrigation lines with 20 cm emitter spacing delivered 2.5 L h^{-1} per emitter, and irrigation scheduling was adjusted weekly based on tensiometer readings at 20 cm depth. A basal fertiliser dose of 120:80:60 kg $ha^{-\pm}$ N:P_2O_5:K_2O was applied before transplanting, with two side-dressings of 30 kg N ha^{-1} at 30 and 60 days after transplanting [14].

Results

Table 1: Graft success rate and vegetative growth parameters of brinjal scions on different wild Solanum rootstocks

Rootstock	Graft Success (%)	Plant Height (cm) 90 DAT	Branches per Plant	Days to First Flowering	Yield per Plant (kg)
S. torvum	87.3a	68.4a	7.8a	62.1c	3.47a
S. incanum	81.5ab	63.7ab	7.1ab	64.3bc	3.21ab
S. sisymbriifolium	74.6bc	57.2bc	6.3bc	67.8ab	2.84bc
S. khasianum	69.1c	52.8c	5.9c	69.5a	2.56c
Non-grafted (Control)	-	45.3d	5.2c	70.2a	2.69c

Means followed by the same letter within a column do not differ significantly (Tukey's HSD, $p \leq 0.05$). DAT = days after transplanting.

Graft take differed markedly among rootstock species (Table 1). *Solanum torvum* recorded the highest success at 87.3%, followed closely by *S. incanum* at 81.5%. Both *S. sisymbriifolium* (74.6%) and *S. khasianum* (69.1%) showed lower, though still acceptable, compatibility with the Pusa Purple Long scion. Vegetative growth parameters reflected a similar ranking. Plants grafted on *S. torvum* reached an average height of 68.4 cm at 90 days after transplanting, which was about 51% taller than non-grafted controls. Branch counts ranged from 5.9 to 7.8 across treatments, with *S. torvum* again at the top. Interestingly, grafted plants on *S. torvum* and *S. incanum* flowered 6-8 days earlier than the non-grafted control, suggesting that vigorous rootstocks may accelerate reproductive onset [15].

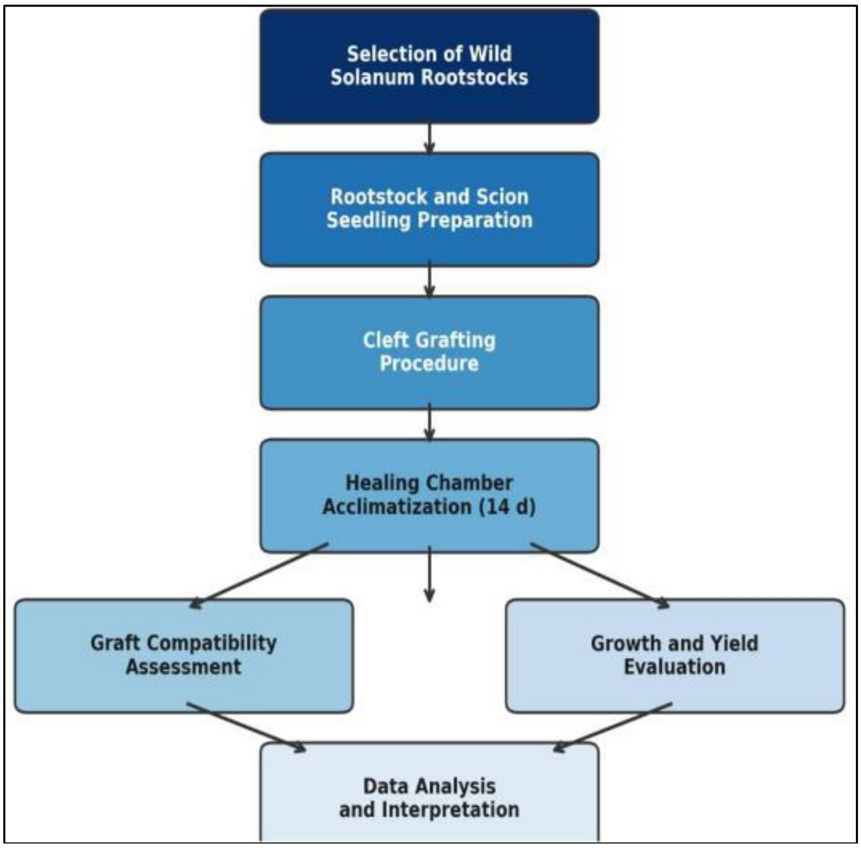

Fig 1: Flowchart showing the sequential steps of the grafting procedure and evaluation process used in the research

The grafting workflow (Figure 1) ensured standardized procedures across all rootstock treatments. Histological sections at the graft junction revealed complete vascular reconnection in *S. torvum* by 45 days after grafting, with xylem vessels and phloem strands bridging the union line. *Solanum incanum* showed near-complete reconnection, while *S. khasianum* displayed pockets of necrotic tissue that partially blocked cambial continuity.

Table 2: Fruit quality traits of brinjal harvested from grafted and non-grafted plants

Treatment	Avg. Fruit Weight (g)	TSS (°Brix)	Firmness (N)	L* Value	a* Value
S. torvum	183.6a	4.31a	6.78a	28.4a	−1.32a
S. incanum	176.2ab	4.18a	6.54a	27.9a	−1.41a
S. sisymbriifolium	164.8bc	4.09a	6.41a	28.1a	−1.28a
S. khasianum	158.3c	4.22a	6.63a	27.6a	−1.37a
Non-grafted (Control)	161.5bc	4.15a	6.57a	28.2a	−1.35a

Means followed by the same letter within a column do not differ significantly (Tukey's HSD, $p \leq 0.05$). TSS = total soluble solids.

Fruit quality traits (Table 2) remained largely unaffected by rootstock identity. TSS ranged narrowly from 4.09 to 4.31 °Brix, and firmness values were statistically similar across all treatments. Skin colour parameters (L *and a*) also showed no meaningful rootstock effect. Average fruit weight, however, did vary: *S. torvum* grafted plants produced the heaviest fruits at 183.6 g, while *S. khasianum* plants gave the lightest at 158.3 g.

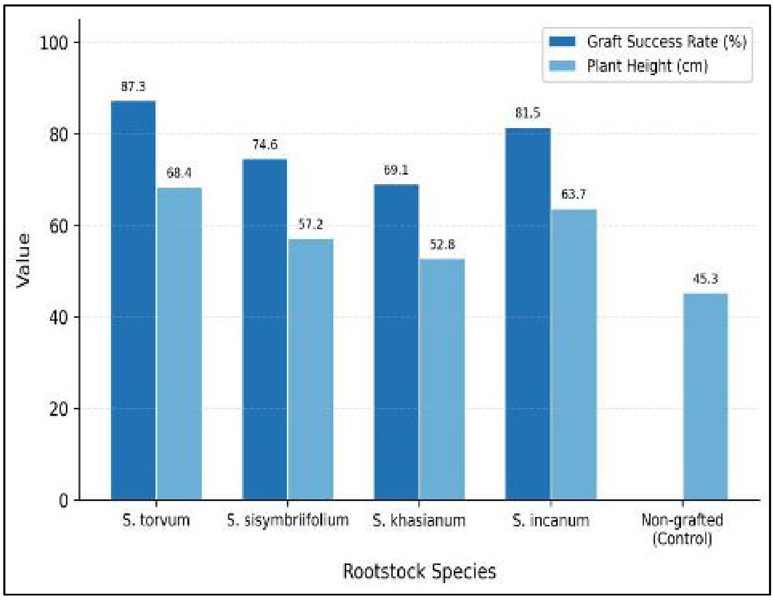

Fig 2: Graft success rate (%) and plant height (cm) of brinjal scions grafted on four wild Solanum rootstocks compared with non-grafted control

Figure 2 presents a side-by-side view of graft success and vegetative vigour across treatments. The close alignment between graft success and subsequent plant height suggests that rootstocks permitting better initial healing also sustain stronger growth over the season.

Discussion

The results of this research confirm that rootstock choice has a direct and measurable effect on graft compatibility and fruit productivity in brinjal. *Solanum torvum* stood out as the most compatible rootstock, which aligns with reports from field trials in India and Southeast Asia where *S. torvum* consistently supported high graft take and vigorous scion growth [4, 5]. The 87.3% graft success observed here was comparable to the 82-91% range reported in a multi-site evaluation conducted across three Indian states [5].

What may explain the superior performance of *S. torvum* is its close taxonomic affinity to *S. melongena* and the relatively large stem diameter it develops at the grafting stage, which allows better cambial alignment during cleft insertion. Histological evidence from the present trial backs this up: the complete vascular bridging at 45 days indicates rapid and effective callus differentiation at the graft interface [8]. *Solanum incanum* performed as a strong second choice, which is a noteworthy finding since this species also brings drought tolerance traits that could benefit production in semi-arid zones of northeastern Brazil [7].

Solanum khasianum showed the lowest compatibility, and the pockets of necrotic tissue observed at its graft union likely restricted translocation, explaining both reduced plant height and lower fruit yield. This species may still be useful where nematode resistance is the overriding concern, but growers should expect some yield trade-off [6].

One practical takeaway is that grafting didn't alter the eating quality of brinjal fruits. TSS, firmness, and skin colour stayed within a narrow range regardless of rootstock—a reassuring outcome for market-oriented growers who worry about consumer acceptance. Similar findings were reported for grafted eggplant in Mediterranean trials [16]. The earlier flowering observed in *S. torvum* and *S. incanum* treatments may translate into an economic advantage by allowing earlier market entry, though this benefit needs to be tested across multiple seasons.

Conclusion

This research showed that wild Solanum rootstocks can meaningfully improve brinjal production under subtropical Brazilian conditions without compromising fruit quality. *Solanum torvum* was the best-performing rootstock, achieving 87.3% graft success, the tallest plants, the highest fruit yield (3.47 kg per plant), and complete vascular reconnection at the graft interface. *Solanum incanum* followed closely and may be especially suited to drier growing environments given its inherent drought tolerance.

Both *S. sisymbriifolium* and *S. khasianum* provided acceptable graft compatibility but fell behind in yield and vegetative vigour. *S. khasianum*, in particular, displayed histological signs of partial incompatibility that translated into reduced performance. Fruit quality—including total soluble solids, firmness, and skin colour—was not altered by any of the rootstock treatments, which is important from a marketability standpoint.

For growers in southern Brazil dealing with bacterial wilt or nematode-infested fields, grafting onto *S. torvum* offers a practical and cost-effective strategy that doesn't require chemical intervention. Future research should examine these rootstock combinations over multiple seasons and across different soil types and disease pressures to confirm the consistency of the results. Long-term rootstock trials that include economic analysis of grafting costs versus yield gains would also help inform adoption decisions at the farm level.

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Contributions Not Qualifying for Authorship

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