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Implications of different dormancy-breaking treatments to enhance the germination of Turkey berry (*Solanum torvum* Swartz)

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Abstract

Solanum torvum, known as turkey berry, holds significant potential in introgression breeding, grafting technology, pharmaceuticals, and nanotechnology. However, the dormancy issue in *Solanum torvum* seeds must be addressed to utilize its potential fully. Various dormancy-breaking treatments, such as hot water soaking, scarification, stratification, and chemical and hormonal treatments, were applied at different concentrations and durations to enhance seed germination. Among the treatments, gibberellic acid at 1500 ppm for 24 hours showed the highest germination rate of 99 %. It also improved other seedling quality parameters, including root length (1.9 cm), shoot length (3.8 cm), dry matter production (3.9 g), vigour index I (574), vigour index II (386), and speed of germination (8.7). The findings from this study provide valuable insights into improving the germination of *Solanum torvum* seeds, which are crucial for their seed production and effective use in agriculture.

Keywords

dormancy; germination; gibberellic acid; turkey berry

Introduction

Solanum torvum (turkey berry) is a perennial shrub native to Latin America and belongs to the Solanaceae family. It is widely spread across Asia, Africa and Australia. The tender, immature fruit is consumed as a vegetable in India, Malaysia, and China and is the most popular vegetable in Thailand. The crop is frequently seen on roadside, foothills, gardens, backyards, etc (1). It holds numerous potential in various fields as a rootstock for eggplant, exhibiting high grafting compatibility with a 95 % survival rate (2). The robust root system allows the plant to tolerate various soil-borne pathogens, low temperature, and root-knot nematode and adapts well to different ecological niches, including contaminated soils.

Furthermore, the plant is an essential genetic resource for plant breeding, and its wild genetic characteristics are utilized in the introgression breeding of eggplant (3). *Solanum torvum* is an important medicinal plant widely used in folk medicine. Various secondary metabolites from the fruits, leaves and stems were utilized in food, pharmaceuticals and cosmetics preparations.

Though it has numerous potentials, the full benefits of turkey berries remain unveiled due to poor and irregular germination caused by dormancy in the seeds. Because of this, the area under cultivation of turkey berries is very meagre. The study of seed dormancy and its enhancement is essential to increasing seed production. Currently, only scanty information regarding the dormancy breaking and germination of the turkey berry seeds is available. The previous research revealed that different accessions of *Solanum torvum* seeds exhibited varying results on germination, and the freshly harvested seed didn't germinate in normal conditions (3–6). Because of the above capability of turkey berry and to justify its potential, it is necessary to break the dormancy and reveal its germination potential. Therefore, it is essential to determine the crucial dormancy-breaking treatments that enhance the germination of turkey berry seeds. Hence, the present study aimed to identify suitable dormancy-breaking treatments for turkey berries.

Materials and Methods

The study was conducted at Horticultural College and Research Institute for Women, Tiruchirappalli, in April 2024. Physiologically matured turkey berry fruits were collected from the Coimbatore region, Tamil Nadu, India and the seeds were extracted from the fruits after overnight fermentation. The seeds settled down, separated from the pulp using a mesh and washed 2 to 3 times. The seeds were shade-dried until they reached about 8 % moisture content for safe storage and were utilized for further examination. The seeds were subjected to physical, physiological and chemical treatments at varied concentrations and durations. After the treatment, the seeds were subjected to a germination test in a petri dish at 25 ± 2 °C. Petri dishes were watered regularly to maintain moisture throughout the test period (7). For each treatment, 100 seeds were tested with four replications. The untreated seeds served as a control.

Treatments with a level of factors evaluation

The dormancy-breaking treatments examined were physical (hot water soaking, acid scarification), Stratification treatment (cold & warm stratification), chemical treatment (KCl, NaCl, KNO_3, $NaNO_3$ and Thiourea) and hormonal treatments (GA_3, IAA and Ethrel). The treatment was imposed at five to six levels of concentration (L_1, L_2, L_3, L_4, L_5) with four to ten levels of duration (D_1, D_2, D_3……..D_{11}) either in time/ days as follows.

Physical treatment

Hot water treatment

The seeds were dipped in boiled water (boiled up to the boiling point and taken out of the flame) for 11 duration levels viz., D_1: 1 min, D_2: 2 min, D_3:3 min, D_4: 4 min, D5: 5 min, D_6: 10 min, D_7: 20 min, D_8: 30 min, D_9: 40 min, D_{10}: 50 min and D_{11}: 60 min.

Acid scarification

The seeds were sacrificed using sulphuric acid at six levels concentrations viz., L_1:5 %, L_2:10 %, L_3: 20 %, L_4: 30 %, L_5: 50 % and L_6: 60 % for 11 durations of levels D_1: 1min, D_2: 2 min, D_3:3 min, D_4: 4 min, D_5: 5 min, D_6:10 min, D_7: 20 min, D_8: 30 min, D_9: 40 min, D_{10}: 50 min and D_{11}: 60 min.

Stratification

Cold and warm Stratification

The seeds were placed at two temperature regimes of L_1:5℃ and L_2:25°C respectively for a period of D_1: 2days, D_2: 4days, D_3: 6days, D_4: 8days, D_5: 10days, D_6: 12days, D_7: 14days and D_8: 16days respectively.

Chemical treatment

All light substituting chemicals such as KCl, NaCl, KNo_3, $NaNo_3$, and thiourea were the seeds were soaked in different concentrations (L_1: 0.5 %, L_2:1 %, L_3:1.5 %, L_4:2 % and L_5: 5 %) for following durations of (D_1: 12hr, D_2: 24hr, D_3: 36hr and D_4: 48hr).

Hormonal treatment

The seeds were soaked in GA_3, IAA, and Ethrel solution at the concentrations of (L_1: 250 ppm, L_2: 500 ppm, L_3: 1000 ppm, L_4: 1500 ppm and L_5: 2000 ppm) at the same level of durations followed by chemical treatment. After all the treatments were imposed, the seeds were subjected to germination tests as per ISTA 2015. A seed was considered to be germinated when the radical length exhibited more than 1 mm. Germination test was evaluated from 4 to 14 days as recommended for other Solanaceous crops (7).

Evaluation and data processing

At the end of the germination test, the physiological seed quality parameters viz., germination (%), fresh ungerminated seeds (%), root & shoot length expressed in cm, and dry matter production expressed in mg/10 seedlings were recorded and the vigour index I and II were calculated. The germination speed was determined using Maguire's formula based on the 4 to 14-day count. Data on the above seed quality parameters were collected and the percentage data were transferred to Arcsine transformation. The experiment was conducted using a factorial, completely randomized design. The critical difference was calculated at a 95 % probability level with significant data indicated an asterisk (*) and non-significant denoted at NS.

Results and Discussion

Effect of dormancy breaking treatment on the S. torvum seeds

The result indicated that the physical, stratification, chemical and hormonal treatments didn't enhance germination in *Solanum torvum* seeds (Table 1). Various concentrations and durations were tested, ranging from minimum to maximum levels, but no signs of germination were observed. Although hot water treatment helped soften the seed coat and enhance water uptake, even extending the treatment to 60 mins yielded no positive results regarding germination. Acid scarification is generally considered a quick and reliable method for breaking seed coat-imposed dormancy. Sulphuric acid (H_2SO_4) is particularly effective in softening hard seed coats. However, in the case of *S. torvum*,

Table 1. Impact of dormancy breaking treatments over *S. torvum* seeds.

Dormancy breaking treatments	Response of dormancy breaking treatments over germination (+/-)
Fresh seeds	-
Hot water soaking	-
Acid scarification	-
Cold & warm stratification	-
Soaking in KNO_3	-
Soaking in KCl	-
Soaking in NaCl	-
Soaking in $NaNO_3$	-
Soaking in thiourea	-
Soaking in indole acetic acid	-
Soaking in ethrel	-
Soaking in gibberellic acid	+

even the seeds were scarified using 60 % H2SO4 for 60 min, which resulted in the seed coat rupture but didn't showcase any germination. Cold and warm stratification are often effective methods for promoting germination in the dormant seeds (8,9). In this study, *S. torvum* seeds remained ungerminated even after extending stratification periods to 10 days at 5 °C and 21°C. Similarly, pre-chilling at 0 °C for a week also resulted in zero germination (4), while related species like *S. incanum* and *S. arianthum* showed 100 % germination under similar conditions.

Chemical methods involve soaking the seeds in chemicals and growth regulators, which are known to break dormancy and enhance germination in various species (10, 11). Nitrogenous chemicals such as nitrates of potassium, calcium, sodium and thiourea effectively reduce dormancy. They are readily available, inexpensive, have high dissolving capability, and alter water potential, thereby regulating seed germination. However, regarding *S. torvum*, no germination enhancement was noticed in all the chemicals, irrespective of concentration and soaking duration. However, Cutti (5) reported that treating stored *Solanum torvum* seeds with a low concentration of 0.2 % KNO_3 resulted in a 97 % germination rate, likely due to the treatment imposed on stored *S. torvum* seeds. These results suggest that *S. torvum* does not exhibit physical dormancy or seed coat-imposed dormancy.

Plant growth regulators play a crucial role in breaking dormancy and enhancing germination. The most commonly used plant growth regulators are gibberellic acid (GA_3), Indole Acetic Acid (IAA) and ethrel. Among these growth regulators, Gibberellic acid is a widely used phytohormone for promoting the germination of dormant seeds that require chilling and light. Therefore, it is often referred to as a light-substituting chemical. The most commonly used form of gibberellic acid is GA_3, a tetracyclic diterpenoid compound prominently used to stimulate seed germination (12, 13). In this study, *S. torvum* seeds treated with IAA and ethrel did not improve germination, whereas GA_3 had a significant positive effect. The International Seed Testing Association recommends GA_3 treatment for breaking dormancy in many crops (14). Various concentrations and soaking durations of GA_3 have shown improved germination rates in many Solanum species (15).

The seeds treated with GA_3@ 1500 ppm with a soaking duration of 24 hrs had maximum germination of 99 % followed by 1000 ppm (95 %) and 2500 ppm (92 %) (Table 2). The lower GA_3 concentration of 500 ppm did not affect breaking dormancy as that of untreated control with nil germination in any soaking durations. As for soaking durations, increasing the duration beyond 24 hrs had a negative effect irrespective of different levels of GA_3 concentration. It was also noticed that the GA_3 concentration beyond 1500 ppm had a significant negative impact and reduced the germination and other seedling parameters in turkey berry seeds, likely due to the toxic effects of the chemical at higher concentrations. The effect of increased

Table 2. Response of *Solanum torvum* towards different concentrations of gibberellic acid – dormancy breaking treatment..

Concentration of GA_3	Soaking hours	Germination (%)	Fresh ungerminated seed (%)	Root length (cm)	Shoot length (cm)	DMP (mg/10 Seedlings)	Vigour index - I	Vigour index - II	Speed of Germination
T_0-Control (Water soaking)	12	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	24	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	36	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	48	0 (2.87)	100 (87.14)	0	0	0	0	0	0
Mean		0 (2.87)	100 (87.14)	0	0	0	0	0	0
T_1- GA3 500 ppm	12	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	24	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	36	0 (2.87)	100 (87.14)	0	0	0	0	0	0
	48	0 (2.87)	100 (87.14)	0	0	0	0	0	0
Mean		0 (2.87)	100 (87.14)	0	0	0	0	0	0
T_2-GA3 1000 ppm	12	90 (71.69)	10 (18.44)	1.8	3.4	3.8	468	342	7.3
	24	95 (77.50)	5 (12.93)	1.7	3.4	3.8	485	361	7.5
	36	89 (77.50)	11 (19.38)	1.7	2.9	3.2	409	285	4.2
	48	84 (73.77)	16 (23.32)	1.4	3.4	3.2	403	269	3.9
Mean		90 (71.66)	11 (18.51)	1.7	3.3	3.5	441	314	6

T_3-GA3 1500 ppm	12	95 (77.50)	5 (12.93)	1.7	3.6	3.8	504	361	8.4															
	24	99 (84.25)	1 (5.74)	1.9	3.8	3.9	574	386	8.7															
	36	84 (66.23)	16 (23.84)	1.4	3.2	3.4	360	286	3.0															
	48	80 (63.47)	20 (26.57)	1.3	2.4	3.2	319	256	2.8															
Mean		90 (72.87)	11 (17.27)	1.6	3.3	3.6	439	322	6															
T_4-GA3 2000 ppm	12	92(73.77)	8 (16.44)	1.4	3.2	3.4	423	313	3.2															
	24	83 (65.94)	17 (24.09)	1.4	3.2	3.4	382	282	3.4															
	36	80 (63.47)	20 (26.57)	1.4	2.4	3.2	304	256	2.3															
	48	75 (60.03)	25 (29.99)	1.3	2.0	2.8	248	210	2.1															
Mean		83 (65.79)	18 (24.28)	1.4	2.7	3.2	339	265	3															
SEd	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**	**T**	**S**	**T×S**
	0.95	0.85	1.90	0.14	0.12	0.27	0.02	0.01	0.04	0.03	0.02	0.06	0.03	0.02	0.06	4.08	3.65	8.17	3.01	2.70	6.03	0.10	0.09	0.21
CD (P=0.05)	1.93**	1.73**	3.85**	0.27**	0.24**	0.54**	0.04**	0.03**	0.08**	0.06**	0.05**	0.12**	0.06**	0.05**	0.12**	8.25**	7.38**	16.51**	6.10**	5.45**	12.20**	0.21**	0.19**	0.57**

******- Highly significant at 5 % level, Figures in parenthesis indicate arc sine transformed value.

concentration and prolonged soaking duration negatively impact the germination of *Solanum torvum* and *Solanum nigrum* (16). Therefore, it is evident that the dormant *S. torvum* seeds are GA_3 dependent and responded positively to the exogenous application of GA_3 in overcoming the dormancy and enhanced germination (Fig. 1). At the same time**,** other treatments, viz., Hot water soaking, scarification, stratification and other concentration did not influence dormancy.

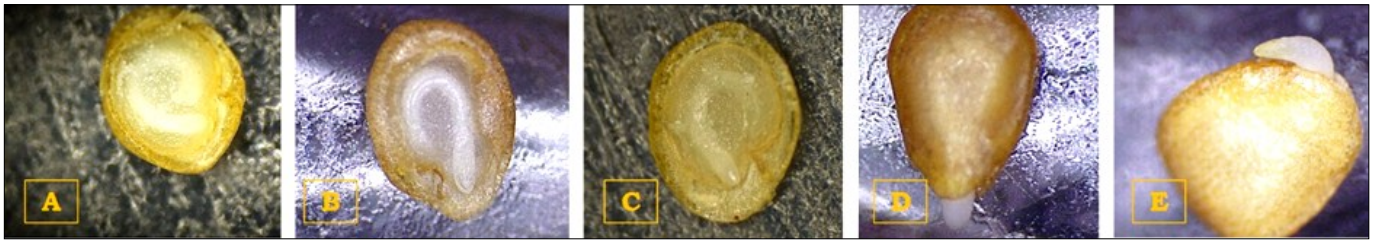

Fig. 1. Impact of gibberellic acid over *S. torvum* seeds. (**A**) Control even after 14 days, (**B**) 1st day, (**C**) 2nd day, (**D**) 3rd day, (**E**) 4th day.

Conclusion

Tomato and brinjal are crucial crops for human consumption, but their survival rate is typically limited to 4 to 5 months. Various soil pathogens and pests often affect these plants during the cropping period. Enhancing their production, productivity, and lifespan is essential to meet the demands of a growing population. One promising approach involves improving the germination of *Solanum torvum*, which plays a significant role as a rootstock in grafting technology for tomato and brinjal. By enhancing *Solanum torvum* germination, rootstock producers, breeders, and farmers can benefit from improved crop cultivation, production, and commercialization. Therefore, the dormancy-breaking treatments are crucial for seed production and the effective use of *Solanum torvum* in agriculture.

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Authors' contributions

MR carried out the overall research work. A provided the chemicals and guidance for experimenting. KR participated in the design and statistical analysis. K facilitated the acquisition of seed samples and guided the experiment. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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