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Screening of Amla (*Phyllanthus emblica* L.) varieties for salinity tolerance by growth and physiological parameters

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Abstract

Amla identified as a salt tolerant fruit crop prime candidate for thriving in saline soils however its tolerance levels vary upon cultivars. The aim of this study is to evaluate the response of Amla (*Phyllanthus emblica* L.) varieties to various salinity levels. This experiment was conducted with five Amla cultivars viz., Coimbatore Local, Chakiya, Kanchan Krishna and NA-7 at four different salinity levels (control, 4, 8, 12 dS m⁻¹) by using pot culture method. Parameters viz., plant height (cm), plant spread (cm), stem diameter (cm), number of branchlets, leaf area (cm²), leaf length (cm), relative water content (per cent) and survival (per cent) were taken after three months. The results showed that the highest plant height (92.71cm), plant spread (59.79cm), stem diameter (1.74 cm), number of branchlets (51.37), leaf area (0.486cm²), leaf length (1.213cm), relative water content (86.31per cent) and survival (92.74per cent) in Chakiya control (V₂C₁). It showed that all parameters were decreased with increasing salinity concentration. From this research it is concluded that amla depending on cultivars withstand upto 12 dS m⁻¹ with survival rate ranked in order as follows Chakiya>NA-7>Kanchan>Krishna> Coimbatore Local.

Keywords: Amla varieties, salinity, growth parameters, relative water content

Introduction

Amla (*Phyllanthus emblica* L.) also known as Aonla or Indian gooseberry is native to tropical South-Eastern Asia. It is a highly valued fruit crop renowned for its exceptional medicinal and nutritive properties mentioned in ancient Indian mythological literatures like Vedas, Shivpuran, Askandhpuran, Padmapuran, Ramayana, Kadambari, Charak Samhita, Sushrut Samhita, etc., considered as Amrit Phal (life giving fruit) (Bhat *et al.*, 2019) [2]. It is the second highest natural source of Vitamin C (400 to 1500 mg/100 g fruit pulp) (Saini *et al.*, 2019) [16]. With a total area under cultivation of 92,000 ha India produced 1,046 thousand metric tonnes (MT) of gooseberries. The major amla producing states include Uttar Pradesh, Madhya Pradesh, and Tamil Nadu accounting for 75% of the total gooseberry production in India (NHB, 2022) [12]. NA-6, NA-7, NA-8, NA-9, NA-10, Banarasi, Chakaiya, Krishna, Francis, Kanchan, Gujarat-1, Gujarat-2, Goma Aishwarya, Neelam, Desi, Bansi red, and Laxmi-52 are some of the common varieties cultivated in various parts of India (Tewari *et al.*, 2023) [18]. Globally, salt affected land is expanding (Mandal *et al.*, 2018) [9], with predictions suggesting that 40% to 50% of the Earth's surface may face drought and salinity stress by 2025 (Martinez *et al.*, 2024) [11]. In India, approximately 6.73 million hectares are left barren due to salinity, heavily impacting several states (CSSRI, 2020) [5].

Salinity induces osmotic stress, restricting water uptake and leads to accumulation of toxic ions. It causes stunted growth, poor yield and quality. It leads to overproduction of Reactive Oxygen Species (ROS) resulting in oxidative stress that damages vital cellular structures. Tolerant fruit crops use various physiological and biochemical defense mechanisms to overcome these. They include osmotic adjustment via the accumulation of compatible solutes such as proline to maintain turgor pressure and activation of antioxidant enzymes (peroxidase, catalase, superoxide dismutase) to scavenge excess ROS (Patel *et al.*, 2011) [13]. Since conventional management by

using chemical amendments are costly and temporary. Cultivation of salt tolerant fruit crops presents a sustainable alternative as amla is identified as a tolerant fruit crop capable of thriving in saline soils.

Although amla have significant potential for cultivation in salt-affected areas, the specific mechanisms of tolerance vary markedly among different intra-specific varieties. There remains a crucial knowledge gap regarding the comparative salinity tolerance of these specific cultivars. To address this, the present study five prominent amla varieties under varying controlled levels of salinity stress to elucidate the mechanisms and most suitable tolerant cultivars.

Materials and Methods

The present investigation was carried out at North Farm within the Division of Horticulture, Karunya Institute of Technology and Sciences (KITS) located in Coimbatore, Tamil Nadu, India at 10.9362° N, 76.7441° E during 2025-2026. Experiment was conducted in five varieties of amla. It was replicated thrice with five plants per replications in a Factorial Randomized Block Design (FRBD) with twenty treatment combinations.

Materials collection & preparation

Eight months old amla seedlings of five different cultivars (Krishna, Kanchan, Chakiya, NA-7 & Coimbatore Local) collected from Periyakulam and Velliangiri. It was transplanted in November 2025. Leaf samples were collected and analysed in March 2026 after three months from date of imposition. Salinity levels were maintained following procedure given by Meena *et al.* (2019) ^[10] adding NaCl₂, the equivalent weights are multiplied by the number of equivalents and dissolved in one litre per pot. Example, for 8 dSm⁻¹ or 40 meq /litre of NaCl₂ = 58.5 x 80 = 4,680 mg/l.

Factor details

Varieties	Notation	Salinity concentration (dS m ⁻¹)	Notation
Coimbatore Local	V ₁	Control (0.14)	C ₁
Chakiya	V ₂	4	C ₂
Kanchan	V ₃	8	C ₃
Krishna	V ₄	12	C ₄
NA-7	V ₅		

Treatment details

Notations	Treatment details
V ₁ C ₁	Coimbatore Local @ Control (0.14 dS m ⁻¹)
V ₁ C ₂	Coimbatore Local @ 4 dS m ⁻¹
V ₁ C ₃	Coimbatore Local @ 8 dS m ⁻¹
V ₁ C ₄	Coimbatore Local @ 12 dS m ⁻¹
V ₂ C ₁	Chakiya @ Control
V ₂ C ₂	Chakiya @ 4 dS m ⁻¹
V ₂ C ₃	Chakiya @ 8 dS m ⁻¹
V ₂ C ₄	Chakiya @ 12 dS m ⁻¹
V ₃ C ₁	Kanchan @ Control
V ₃ C ₂	Kanchan @ 4 dS m ⁻¹
V ₃ C ₃	Kanchan @ 8 dS m ⁻¹
V ₃ C ₄	Kanchan @ 12 dS m ⁻¹
V ₄ C ₁	Krishna @ Control
V ₄ C ₂	Krishna @ 4 dS m ⁻¹
V ₄ C ₃	Krishna @ 8 dS m ⁻¹
V ₄ C ₄	Krishna @ 12 dS m ⁻¹
V ₅ C ₁	NA-7 @ Control
V ₅ C ₂	NA-7 @ 4 dS m ⁻¹
V ₅ C ₃	NA-7 @ 8 dS m ⁻¹
V ₅ C ₄	NA-7 @ 12 dS m ⁻¹

Evaluation of physical and chemical properties

Plant height was measured from the base of the plant to the tip of the terminal bud using a standard meter scale. The observations were recorded in centimetres, and the average was calculated for each treatment. Plant spread was recorded using measuring tape. The maximum width of the plant canopy that is widest point and perpendicular width was taken. The average was recorded as plant spread. Stem diameter was measured with digital vernier calliper and average calculated. Number of branchlets per plant was counted manually from the branches that originated from main axis. Leaf area was taken using Leaf Area Meter 211. Relative water content was calculated by the following formula given by Liu *et al.* (2019) ^[3].

$$\text{Relative Water Content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

$$\text{Survival (\%)} = \frac{\text{Number of plants survived}}{\text{Total number of plants}} \times 100$$

The EC (Electrical Conductivity) of soil was maintained in all pots by using an EC meter (Labtronics ISO 9001 – 2008 certified). The factorial and interaction effects were evaluated using analysis of variance (ANOVA). The differences between treatment means have been analysed by using the least significant difference (CD @ 5%) test.

Results and Discussion

Plant height and plant spread

The data in table 1. showed that the varieties and salt concentration significantly affected the plant height and plant spread. The highest (92.71 cm) and the lowest (52.83 cm) plant height were found in V₂C₁ and V₁C₄, respectively. The highest (59.79 cm) and the lowest (33.28 cm) plant spread were also recorded in V₂C₁ and V₁C₄, respectively. These results were related to those obtained by Rao and Singh, (2006) ^[14] in Chakiya variety of Amla. They reported that the lowest plant height (151.40cm) and plant spread (43cm) were found during the highest salinity level of 15 dS m⁻¹.

Stem diameter and number of branchlets

As per data in table 1. there is significant effect of varieties and salinity concentrations on stem diameter and number of branchlets. The highest (1.74 cm) and lowest (1.26 cm) stem diameter were found in V₂C₁ and V₁C₄, respectively. The highest (51.37) and lowest (21.13) number of branchlets recorded are V₂C₁ and V₄C₄, respectively. These results agreed with those obtained by Shukla and Pathak, (1999) ^[17] in different varieties of Amla. They revealed that the stem diameter (Krishna- 1.57cm and Kanchan- 1.21cm) and number of branchlets per plant (Krishna- 125.25 and Kanchan-85) were found under salinity stress.

Leaf area, leaf length and chlorophyll content

According to the data in Table 2. there is significant effect of varieties and salinity concentrations on leaf area, leaf length and chlorophyll content. The highest (0.486 cm²) and lowest (0.246 cm²) leaf area were found in V₂C₁ and V₁C₄, respectively. The highest (1.213) and lowest (0.547 cm) leaf length were found in V₂C₁ and V₁C₄, respectively. The highest (1.213 mg g⁻¹) and lowest (1.63 mg g⁻¹) chlorophyll content were found in V₂C₁ and V₁C₄, respectively. These findings were related to Rao *et al.* (2009) ^[15] in Chakiya variety of Amla. They reported that the highest (1.87 mg g⁻¹) and the lowest (1.72 mg g⁻¹) chlorophyll

content were found in the lowest (0.8 dS m^{-1}) and the highest (15 dS m^{-1}) salinity.

Relative water content and plant survival

The data in Table 2. showed that varieties and salinity concentration have significant effects on relative water content and survival. The highest (51.37 per cent) and lowest (21.13 per cent) relative water content were recorded in V_2C_1 and V_4C_4 , respectively. Figure 1. illustrated that the survival percentage was significantly affected by varieties and salinity concentration. The highest (92.74 per cent) and lowest (56.27 per cent) survival

rate was found in V_2C_1 and V_1C_4 respectively. These results related with those reported by Bajpai *et al.* (2017)^[1] in Mango. They concluded that the highest (95.16 per cent) and the lowest (85.85 per cent) relative water content were found in control and salinity stressed plants respectively.

Similar results have been found that reduced morphological and physiological parameters in response to increased salinity in pomegranate (Liu *et al.*, 2019)^[3], grape (Fozouni *et al.*, 2012)^[4], gooseberry (Joshi *et al.*, 2022)^[6], date palm (Kharusi *et al.*, 2017)^[7], passion fruit (Lima *et al.*, 2023)^[8], citrus (Patel *et al.*, 2011)^[13].

Table 1: Effect of varieties and salinity concentrations on plant height, plant spread, stem diameter and number of branchlets

Treatments	Plant height (cm)	Plant spread (cm)	Stem diameter (cm)	Number of branchlets / plant
Varieties				
V ₁	69.802	44.375	1.395	30.023
V ₂	85.515	54.330	1.628	47.058
V ₃	74.100	47.105	1.547	36.220
V ₄	72.128	45.938	1.495	31.965
V ₅	79.675	50.755	1.580	40.053
SE (d)	0.521	0.408	0.007	0.259
CD (5%)	1.055	0.826	0.015	0.525
Salt concentration				
C ₁	86.196	55.596	1.654	44.202
C ₂	79.862	50.888	1.572	39.370
C ₃	73.116	46.062	1.484	34.792
C ₄	65.802	41.456	1.406	29.890
SE (d)	0.466	0.365	0.006	0.232
CD (5%)	0.944	0.739	0.013	0.469
Interaction (Varieties x Salt concentration)				
V ₁ C ₁	81.65	52.66	1.57	37.64
V ₁ C ₂	76.27	48.43	1.43	31.35
V ₁ C ₃	68.46	43.13	1.32	27.83
V ₁ C ₄	52.83	33.28	1.26	23.27
V ₂ C ₁	92.71	59.79	1.74	51.37
V ₂ C ₂	87.46	55.54	1.65	48.74
V ₂ C ₃	83.53	52.62	1.59	45.27
V ₂ C ₄	78.36	49.37	1.53	42.85
V ₃ C ₁	85.43	55.12	1.66	44.29
V ₃ C ₂	75.92	48.21	1.59	39.46
V ₃ C ₃	69.12	43.55	1.53	33.74
V ₃ C ₄	65.93	41.54	1.41	27.39
V ₄ C ₁	83.67	53.96	1.61	41.53
V ₄ C ₂	76.71	49.07	1.58	35.72
V ₄ C ₃	67.88	42.76	1.44	29.48
V ₄ C ₄	60.25	37.96	1.35	21.13
V ₅ C ₁	87.52	56.45	1.69	46.18
V ₅ C ₂	82.95	53.19	1.61	41.58
V ₅ C ₃	76.59	48.25	1.54	37.64
V ₅ C ₄	71.64	45.13	1.48	34.81
SE (d)	1.042	0.816	0.014	0.518
CD (5%)	2.11	1.652	0.029	1.049

Table 2: Effects of varieties and salinity concentrations on leaf area, chlorophyll content, relative water content and plant survival percentage

Treatments	Leaf Area (cm ²)	Leaf length (cm)	Chlorophyll Content (mg/g)	Relative Water Content (per cent)	Plant survival (per cent)
Varieties					
V ₁	0.298	0.737	1.733	66.180	68.840
V ₂	0.414	1.034	1.838	81.652	84.552
V ₃	0.366	0.805	1.755	66.180	74.332
V ₄	0.337	0.798	1.765	69.765	71.670
V ₅	0.382	0.990	1.795	79.002	82.330
SE (d)	0.003	0.013	0.002	0.355	0.141
CD (5%)	0.005	0.027	0.003	0.719	0.285
Salt concentration					
C ₁	0.426	1.063	1.866	78.612	89.56

C ₂	0.374	0.921	1.814	74.574	77.884
C ₃	0.332	0.806	1.754	71.236	71.512
C ₄	0.305	0.702	1.674	68.446	66.424
SE (d)	0.002	0.012	0.001	0.318	0.126
CD (5%)	0.005	0.024	0.003	0.643	0.255
Interaction (Varieties x Salt concentration)					
V ₁ C ₁	0.357	0.956	1.82	71.54	88.63
V ₁ C ₂	0.316	0.781	1.76	67.29	69.42
V ₁ C ₃	0.273	0.662	1.72	64.16	61.04
V ₁ C ₄	0.246	0.547	1.63	61.73	56.27
V ₂ C ₁	0.486	1.213	1.92	86.31	92.74
V ₂ C ₂	0.425	1.146	1.87	82.75	85.39
V ₂ C ₃	0.386	0.925	1.82	79.63	83.65
V ₂ C ₄	0.359	0.852	1.74	77.92	76.43
V ₃ C ₁	0.439	1.037	1.85	74.29	88.21
V ₃ C ₂	0.375	0.828	1.78	71.36	73.04
V ₃ C ₃	0.338	0.723	1.72	67.91	69.93
V ₃ C ₄	0.311	0.631	1.67	64.38	66.15
V ₄ C ₁	0.397	0.985	1.86	76.35	86.59
V ₄ C ₂	0.358	0.812	1.81	71.85	76.29
V ₄ C ₃	0.307	0.744	1.74	67.34	65.48
V ₄ C ₄	0.286	0.652	1.65	63.52	58.32
V ₅ C ₁	0.453	1.124	1.88	84.57	91.63
V ₅ C ₂	0.396	1.036	1.85	79.62	85.28
V ₅ C ₃	0.357	0.974	1.77	77.14	77.46
V ₅ C ₄	0.322	0.827	1.68	74.68	74.95
SE (d)	0.005	0.026	0.003	0.711	0.282
CD (5%)	0.01	0.053	0.006	1.438	0.571

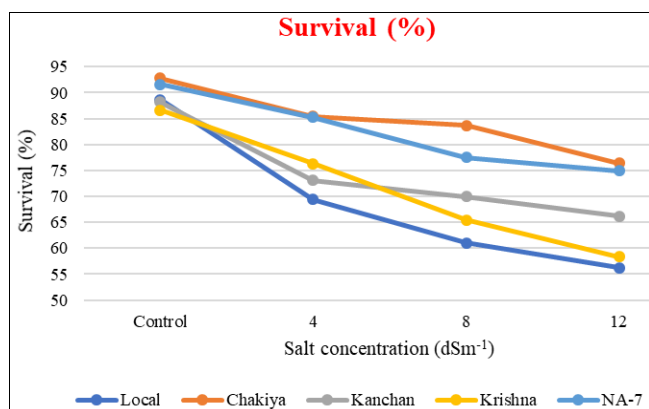


Fig 1: Effect of varieties and salinity concentrations on plant survival percentage.

Conclusion

Under salinity treatments of Control, 4 dS m⁻¹, 8 dS m⁻¹ and 12 dS m⁻¹, the growth and physical parameters of five different amla varieties viz., Coimbatore Local, Chakiya, Kanchan, Krishna and Kanchan were assessed. The results showed that the highest plant height (92.71cm), plant spread (59.79cm), stem diameter (1.74cm), number of branchlets (51.37), leaf area (0.486cm²), leaf length (1.213cm), relative water content (86.31per cent) and survival (92.74per cent). It depicted that the growth and physiological parameters of amla were negatively impacted due to salinity. Chakiya and NA-7 emerged as the most suitable cultivars and Coimbatore local as unfit for cultivation in salt affected soils.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors.

Conflict of Interest

The authors declare no conflicts of interest regarding the content of this publication.

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