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RESEARCH ARTICLE

Salinity tolerance screening of traditional mangoes: Analysis of physiological and biochemical traits for abiotic stress tolerance

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Abstract

The study investigates the salinity stress tolerance of 34 traditional mango accessions from South Kerala. Salinity is a major abiotic stress limiting mango cultivation, especially in coastal and irrigated regions where salt accumulation in soil and water adversely affects growth, yield and fruit quality. Traditional mango varieties, being locally adapted and genetically diverse, may possess inherent tolerance mechanisms that enable survival under saline conditions. Screening these varieties for salinity tolerance through physiological and biochemical traits provides valuable insights for identifying tolerant genotypes. Key parameters such as chlorophyll content, relative water content, electrolyte leakage, proline accumulation and antioxidant enzyme activity serve as indicators of stress response and adaptive potential. Understanding these traits helps in assessing varietal differences in osmotic adjustment, ion regulation and oxidative stress management. The experiment observed significant increases in glycine betaine, proline and total soluble sugar levels under salinity stress, with accession KLM10 exhibiting the highest GB content. Enzymatic antioxidant varied significantly among accessions, with KLM12 displaying the highest catalase activity. The analysis of total chlorophyll content indicated that KLM10 maintained the highest chlorophyll levels under stress. The salinity tolerance index was highest in KLM10. A moderate positive correlation was found between total phenol content, chlorophyll content and TI, suggesting these parameters as potential markers for salinity tolerance. The study of traditional mangoes under salinity stress thus contributes to the selection and conservation of tolerant cultivars, facilitating sustainable mango production and genetic improvement programs aimed at enhancing abiotic stress tolerance.

Keywords: antioxidants; mango; proline; salinity; stress

Introduction

Salinity stress is one of the major abiotic stresses affecting agricultural productivity worldwide. Globally, it is a major abiotic constraint affecting mango production, particularly in arid and semi-arid regions where irrigation with saline water is common. High salt concentrations in the soil impair root function, reduce nutrient uptake and lead to stunted growth, leaf burn and poor fruit yield and quality. In countries where extensive mango-growing areas face declining productivity due to secondary salinization caused by unsustainable irrigation practices. In Kerala, coastal mango orchards are increasingly exposed to salinity intrusion from seawater and rising groundwater salinity, especially in low-lying regions. This regional challenge threatens the growth and fruiting of traditional mango varieties, emphasizing the need for salt-tolerant genotypes and improved water management practices. Plants also face challenges such as low soil osmotic potential, nutritional imbalances, specific ion toxicity and oxidative stress and both Na^+ and Cl^+ ions are primarily responsible for salinity-induced stress in plant (1). These stresses collectively impair physiological, biochemical and molecular processes, leading to compromised plant growth and development (2, 3). This limitation is particularly severe in major fruit-producing countries such as India, China, Brazil, the United States and Spain, which are leading producers of mango (4). It is estimated to be 6.7 million ha of salt affected soils in India.

Mango (*Mangifera indica* L.) is categorized as a highly salt-sensitive species, with adverse effects manifesting at electrical conductivity (EC) levels lower than 1 ms cm^{-1}(5, 6) and it affects about 52 million hectares of land in India and South Asia (7). Previous studies have highlighted the detrimental effects of salinity on various morphological parameters in mango, including plant height, stem girth, number of leaves, leaf area and specific leaf weight (8). Notable examples include the polyembryonic cultivar '13/1', which has demonstrated tolerance to low-quality water and is widely used in Israel (9). In South Africa, the 'Sabre' rootstock continues to be utilised for stabilised mango production (10). Salinity is a concern across many major mango-growing states Haryana, Uttar Pradesh, Orissa, Gujarat, Punjab, Rajasthan, West Bengal, Maharashtra andhra Pradesh, Karnataka, Tamil Nadu and coastal areas of Kerala in India.

The current study aims to explore the salinity stress tolerance of specific traditional mango varieties indigenous to South Kerala in India. Indigenous and traditional fruit mango varieties ensure genetic diversity and sustainable, low-input cultivation while preserving local heritage and unique market value. By simulating saline conditions and evaluating various biochemical and morphological parameters, this research seeks to identify important indicators of salinity tolerance. The understanding of these indicators will aid in the choice and advancement of resilient, salt-resistant mango cultivars, thereby enhancing the longevity and efficiency of mango farming in areas affected by salinity.

Materials and Methods

Plant material

As part of the study, screening of salinity stress tolerance was conducted in selected 34 distinct traditional mango accessions collected from South Kerala, India (Table 1). The experiment was conducted at Farming Systems Research Station, Kerala Agricultural University, Sadanandapuram, Kerala (8°58'54.6"N

Table 1. Site descriptors of the collected 34 traditional mango varieties used in the study

Sl. No.	Accession No.	Agro-climatic Zone	Village/Block	District	State	Latitude	Longitude
1	ALA06	West Coast Plains and Ghat Region	Kayamkulam	Alappuzha	Kerala	9.16101	76.50613
2	ALA07	West Coast Plains and Ghat Region	Kayamkulam	Alappuzha	Kerala	9.16169	76.50541
3	ALA09	West Coast Plains and Ghat Region	Kattanam	Alappuzha	Kerala	9.18457	76.55572
4	ALA13	West Coast Plains and Ghat Region	Nilamperoor	Alappuzha	Kerala	9.48951	76.48849
5	ALA14	West Coast Plains and Ghat Region	Nilamperoor	Alappuzha	Kerala	9.48888	76.49784
6	ALA15	West Coast Plains and Ghat Region	Kainady	Alappuzha	Kerala	9.49642	76.47357
7	ALA20	West Coast Plains and Ghat Region	Kayamkulam	Alappuzha	Kerala	9.4986	76.4384
8	ALA21	West Coast Plains and Ghat Region	Kainady	Alappuzha	Kerala	9.49622	76.47384
9	ALA22	West Coast Plains and Ghat Region	Kainady	Alappuzha	Kerala	9.49426	76.47058
10	ALA23	West Coast Plains and Ghat Region	Kainady	Alappuzha	Kerala	9.49625	76.46954
11	ALA25	West Coast Plains and Ghat Region	Kainady	Alappuzha	Kerala	9.49582	76.47452
12	ALA27	West Coast Plains and Ghat Region	Harippadu	Alappuzha	Kerala	9.28216	76.44491
13	KLM03	West Coast Plains and Ghat Region	Chavara	Kollam	Kerala	8.99355	76.559
14	KLM04	West Coast Plains and Ghat Region	Kottarakkara	Kollam	Kerala	8.97242	76.73567
15	KLM10	West Coast Plains and Ghat Region	Thirumullavaram	Kollam	Kerala	8.89467	76.55787
16	KLM11	West Coast Plains and Ghat Region	Kollam	Kollam	Kerala	8.89614	76.55565
17	KLM12	West Coast Plains and Ghat Region	Kulakkada	Kollam	Kerala	8.32438	76.53449
18	KLM13	West Coast Plains and Ghat Region	Kollam	Kollam	Kerala	8.88358	76.5817
19	KLM15	West Coast Plains and Ghat Region	Thirumullavaram	Kollam	Kerala	8.89733	76.55704
20	KLM17	West Coast Plains and Ghat Region	Kollam	Kollam	Kerala	8.86784	76.84321
21	KLM20	West Coast Plains and Ghat Region	Kollam	Kollam	Kerala	8.88982	76.5753
22	KLM26	West Coast Plains and Ghat Region	Chavara	Kollam	Kerala	8.97498	76.54538
23	KLM27	West Coast Plains and Ghat Region	Chadayamangalam	Kollam	Kerala	8.86743	76.84198
24	KLM28	West Coast Plains and Ghat Region	Chadayamangalam	Kollam	Kerala	8.86743	76.84221
25	KLM29	West Coast Plains and Ghat Region	Chadayamangalam	Kollam	Kerala	8.86322	76.83712
26	KLM31	West Coast Plains and Ghat Region	Chadayamangalam	Kollam	Kerala	8.89743	76.86194
27	KLM33	West Coast Plains and Ghat Region	Thamarakulam	Kollam	Kerala	8.88338	76.58667
28	KLM35	West Coast Plains and Ghat Region	Eravipuram	Kollam	Kerala	816101	76.50613
29	KLM37	West Coast Plains and Ghat Region	Kulakkada	Kollam	Kerala	8.32518	76.42449
30	KLM38	West Coast Plains and Ghat Region	Kilikolloor	Kollam	Kerala	8.18457	76.55572
31	KLM40	West Coast Plains and Ghat Region	Vakkanadu	Kollam	Kerala	8.31143	76.43003
32	PTA01	West Coast Plains and Ghat Region	Karaykkadu	Pathanamthitta	Kerala	9.2695	76.75605
33	TVM01	West Coast Plains and Ghat Region	Navayikulam	Thiruvananthapuram	Kerala	8.35609	76.14395
34	TVM02	West Coast Plains and Ghat Region	Kallara	Thiruvananthapuram	Kerala	8.46083	76.88945

76°48'38.5"E) (Fig. 1) during March 2022 to April 2024. A salinity stress was imposed by the weekly application of 500 mL NaCl (200 mM) to simulate salinity environment. All accessions were grouped in a Completely Randomized Design (CRD) with three replicates. When sensitive cultivars showed severe stress symptoms and perished, data for morphological traits were recorded for up to 60 days. Sampling included collection of the third and fourth leaves from the plant apex to analyze biochemical parameters at the beginning of salinity stress (control, C) and after 21 days of treatment (T). Control plants were not subjected to any stress condition.

Analysis of biochemical traits

Glycine Betain (GB)

Glycine Betaine content was measured by measuring the absorbance at 365 nm using a cold potassium iodide reagent. To tabulate and determine the GB content (µg g^{-1} FW), standard Glycine Betaine solutions (02. - 1 mL) corresponding to 2.0 - 10 µg concentrations were used.

Proline

Proline concentration was analysed using aqueous sulfosalicylic acid and absorbance at 520 nm. The same procedures were applied to the standard Proline solutions (0.2 - 1 mL), which corresponds to a concentration of 2.0 - 10 µg.

Total Soluble Sugar (TSS)

The procedure using cold anthrone solution was used to estimate the total soluble sugars (mg g^{-1} FW). Using glucose as a standard, the absorbance at 620 nm was used to determine the total sugar content.

Non-enzymatic antioxidant valuation

Tannin content

Tannin content was quantified following the procedure using 200 mg of the sample was combined with 20 mL of 50 % methanol and mixed thoroughly. The absorbance of the tannic acid standard solutions and the samples was measured at 760 nm using UV visible spectrophotometer.

Total phenol content

Phenol content was determined using the colorimetric method with the Folin-Ciocalteu reagent.

Anthocyanin content

The total anthocyanin content (mg g^{-1} FW) was determined using ethanolic hydrochloric acid (HCl) was employed as the solvent for extraction.

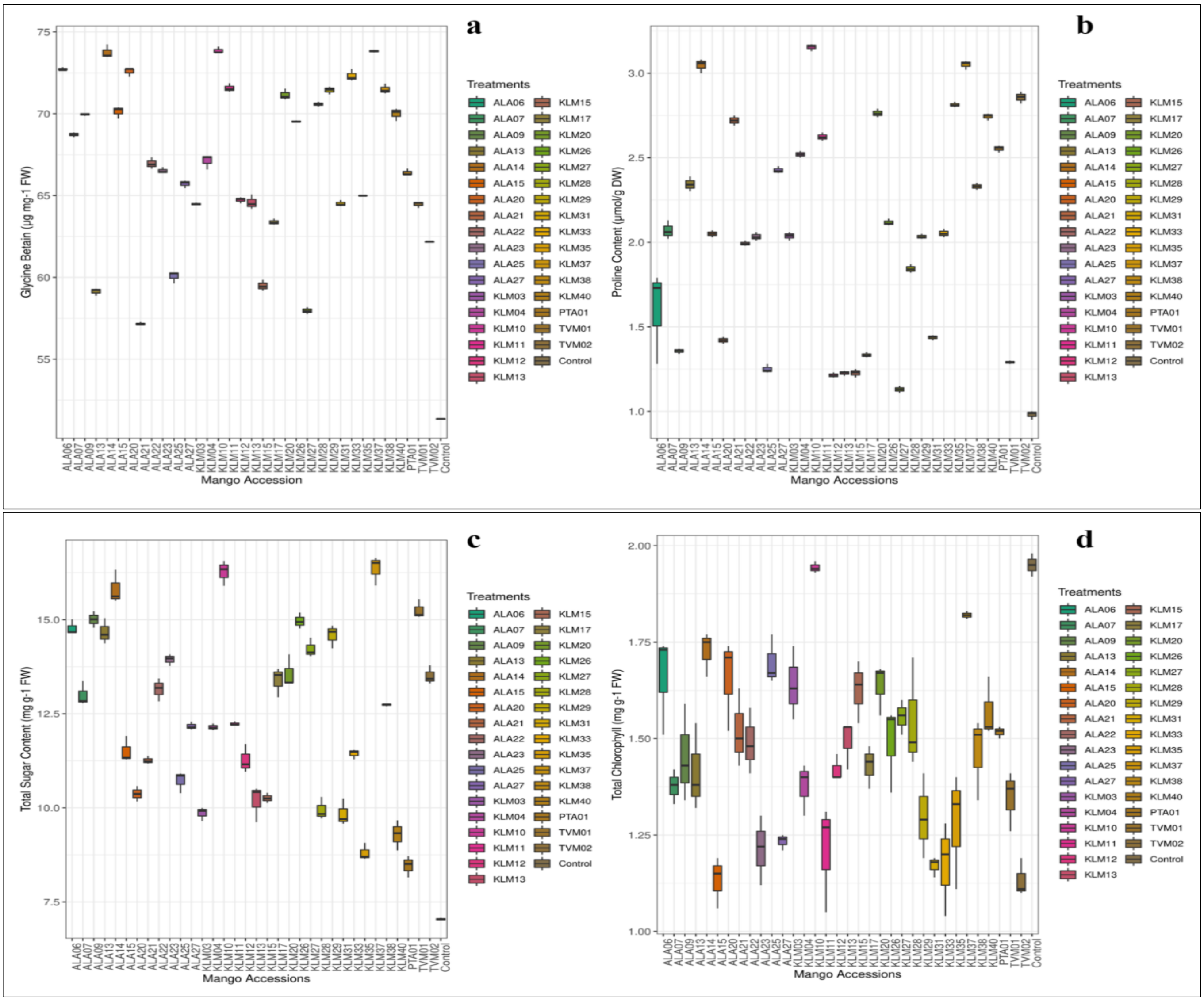

Fig. 1. Accumulation statistics boxplots (DMRT) of (**a**) Glycine Betain (**b**) Proline (**c**) Total Soluble Sugar and (**d**) Total Chlorophyll.

Results

Concentration of solutes and osmolytes

All the mango accessions were subjected to salinity stress in the soil and the amount of organic osmolytes accumulated was estimated to compare with the control. When stress was induced, all the compatible solutes exhibited a statistically significant ($P< 0.05$) (21 days after stress) increase in accumulation (Table 2), the increasing trend was greatest for KLM 10 compared to all other accessions. KLM10 showed the highest mean value of glycine betaine (73.86 µg g^{1} FW). The mean standard error (SE) was 0.149 and the coefficient of variation (cv) was 0.387 % (Fig. 1a). Increase in GB content was exhibited by KLM 10. In the case of proline, the highest mean was observed in treatment KLM 10 (3.15 µg g^{1} FW) (Fig. 1b). Treatment means ranged from 7.04 mg g^{1} FW (Control) to 16.35 mg g^{1} FW (KLM37), with distinct groupings identified through Duncan's multiple range test (DMRT) for total soluble sugar content (Fig. 1c).

Enhanced non-enzymatic antioxidant production under stress conditions

The increased soil salinity leads to a significant rise in the concentrations of tannins, total phenols and anthocyanins in plants (Table 2). Treatment KLM10 emerged with the highest mean (19.60 mg g^{1} FW. In contrast, ALA22 (15.32 mg g^{1} FW) showed lower tannin content, indicating less favourable outcomes (Fig. 2a). Significant variation among all the accessions is observed in total phenol content also, ranging from 8.46 mg g^{1} FW (KLM 33) to 16.35 mg g^{1} FW (KLM 10) (Fig. 2c)

Control mechanisms of enzymatic antioxidants

The treatment means for catalase activity among the different mango accessions varied significantly (Fig. 3a) and Table 2). The highest mean catalase activity was recorded in the accession KLM12, which had an average activity of 45.46 µM H_2O_2 min^{-1} mg^{-1} TP with a standard deviation of 1.018 units.

The highest mean peroxidase activity was observed in the KLM10 accession, with a value of 1.90 µM mg^{1} protein min^{-1} (Fig. 3b). This elevated activity suggests that KLM10 has a robust enzymatic mechanism to mitigate oxidative stress induced by salinity.

The results of the superoxide dismutase (SOD) activity under salinity-induced stress among different mango accessions indicate significant variability (Fig. 3c). Treatment ALA14 showed the highest mean SOD activity at 22.703 ± 0.042 units, with a lower confidence limit (LCL) of 22.381 and an upper confidence limit (UCL) of 23.025.

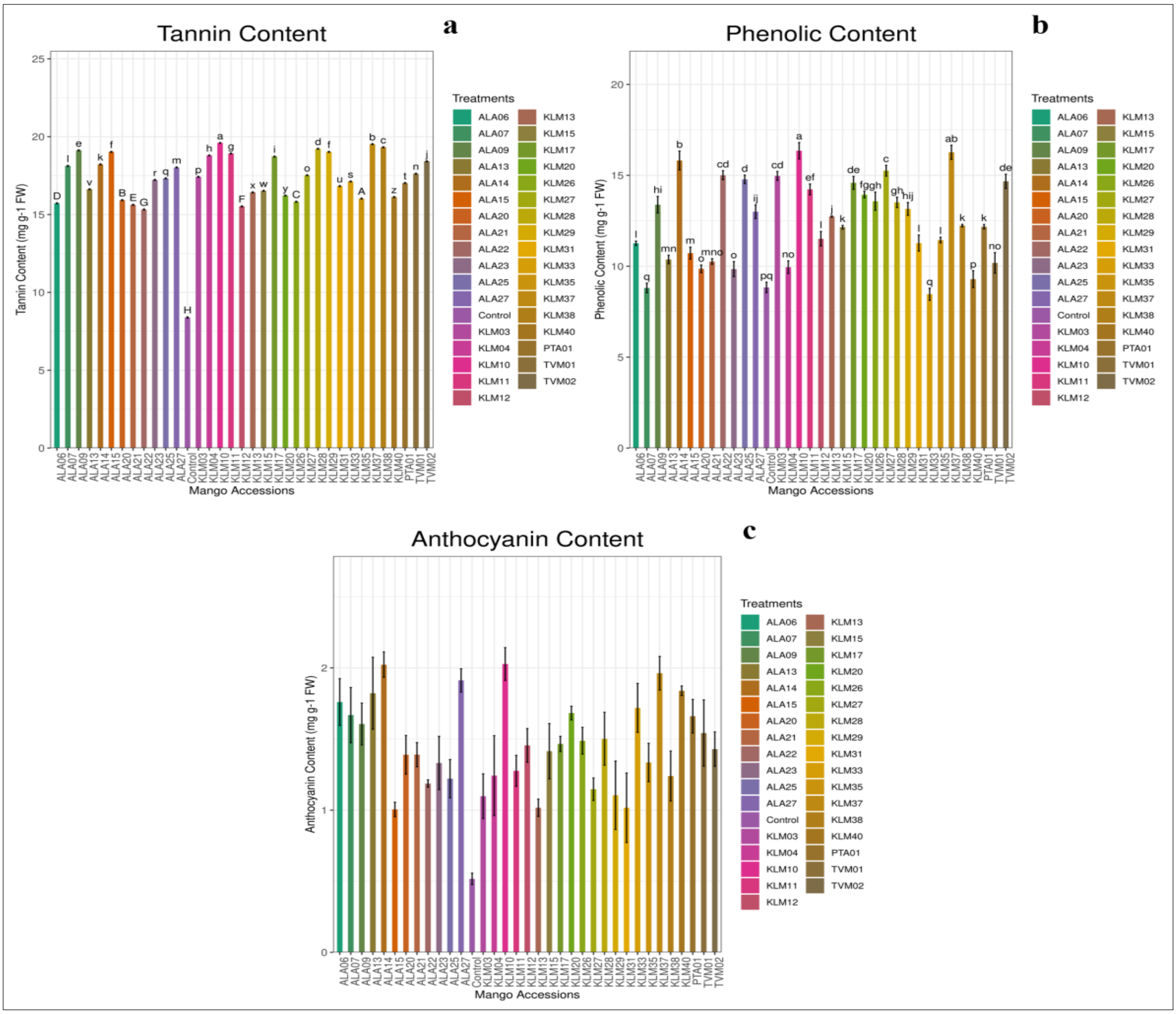

Fig. 2. Bar Plot showing variations in (a) Tannin, (b) Total Phenol and (c) Anthocyanin contents in traditional mango accessions in salinity stress.

Table 2. Oosmolyte, Antioxidant and Chlorophyll content of mango seedlings under salinity stress

Sl. No.	Accession	Proline Content (μmol/g)	Glycine Betain (mg/mg)	TSS (mg g^{-1})	Total Phenol (mg g^{-1})	Tannin (mg g^{-1})	Anthocyanin (mg g^{-1})	Catalase (mg g^{-1})	Peroxidase (mg g^{-1})	Super Oxide Dismutase (mg g^{-1})	Total Chlorophyll (mg g^{-1} FW)
1	ALA06	1.60±0.15	72.73±0.15	14.78±0.15	11.26±0.15	15.72±0.15	1.76±0.15	21.00±0.15	1.29±0.15	22.57±0.15	1.66±0.15
2	ALA07	2.07±0.03	68.73±0.03	13.00±0.03	8.81±0.03	18.12±0.03	1.67±0.03	30.26±0.03	0.91±0.03	20.44±0.03	1.38±0.03
3	ALA09	1.36±0.00	69.96±0.00	15.01±0.00	13.39±0.00	19.12±0.00	1.61±0.00	27.32±0.00	1.23±0.00	20.66±0.00	1.45±0.00
4	ALA13	2.34±0.02	59.14±0.02	14.67±0.02	10.37±0.02	16.62±0.02	1.82±0.02	36.91±0.02	1.14±0.02	20.23±0.02	1.41±0.02
5	ALA14	3.05±0.01	73.75±0.01	15.82±0.01	15.82±0.01	18.22±0.01	2.02±0.01	44.22±0.01	1.54±0.01	22.71±0.01	1.72±0.01
6	ALA15	2.05±0.01	70.13±0.01	11.51±0.01	10.72±0.01	19.02±0.01	1.00±0.01	27.63±0.01	1.10±0.01	20.07±0.01	1.13±0.01
7	ALA20	1.42±0.01	72.58±0.01	10.37±0.01	9.86±0.01	15.92±0.01	1.39±0.01	22.13±0.01	1.15±0.01	20.62±0.01	1.66±0.01
8	ALA21	2.72±0.01	57.15±0.01	11.26±0.01	10.26±0.01	15.62±0.01	1.39±0.01	16.76±0.01	1.10±0.01	21.34±0.01	1.52±0.01
9	ALA22	1.99±0.01	66.96±0.01	13.15±0.01	15.01±0.01	15.32±0.01	1.19±0.01	43.41±0.01	1.16±0.01	20.41±0.01	1.49±0.01
10	ALA23	2.03±0.01	66.52±0.01	13.94±0.01	9.84±0.01	17.22±0.01	1.33±0.01	42.14±0.01	1.16±0.01	22.47±0.01	1.21±0.01
11	ALA25	1.25±0.01	60.06±0.01	10.72±0.01	14.78±0.01	17.32±0.01	1.22±0.01	33.17±0.01	1.15±0.01	21.10±0.01	1.70±0.01
12	ALA27	2.43±0.01	65.72±0.01	12.17±0.01	13.00±0.01	18.02±0.01	1.91±0.01	39.65±0.01	1.07±0.01	21.57±0.01	1.23±0.01
13	KLM03	2.04±0.01	64.47±0.01	9.86±0.01	14.97±0.01	17.42±0.01	1.10±0.01	29.93±0.01	1.10±0.01	20.54±0.01	1.64±0.01
14	KLM04	2.52±0.01	67.12±0.01	12.15±0.01	9.95±0.01	18.80±0.01	1.24±0.01	39.64±0.01	1.06±0.01	19.88±0.01	1.37±0.01
15	KLM10	3.15±0.01	73.86±0.01	16.27±0.01	16.35±0.01	19.60±0.01	2.03±0.01	45.46±0.01	1.90±0.01	22.69±0.01	1.94±0.01
16	KLM11	2.62±0.01	71.57±0.01	12.23±0.01	14.23±0.01	18.92±0.01	1.28±0.01	31.12±0.01	1.15±0.01	20.25±0.01	1.21±0.01
17	KLM12	1.21±0.01	64.73±0.01	11.27±0.01	11.51±0.01	15.52±0.01	1.45±0.01	21.79±0.01	1.25±0.01	20.93±0.01	1.42±0.01
18	KLM13	1.23±0.00	64.58±0.00	10.18±0.00	12.74±0.00	16.42±0.00	1.02±0.00	34.99±0.00	1.13±0.00	20.16±0.00	1.49±0.00
19	KLM15	1.23±0.01	59.49±0.01	10.26±0.01	12.15±0.01	16.52±0.01	1.41±0.01	40.63±0.01	1.04±0.01	20.79±0.01	1.63±0.01
20	KLM17	1.33±0.00	63.38±0.00	13.39±0.00	14.59±0.00	18.72±0.00	1.47±0.00	38.53±0.00	1.04±0.00	20.41±0.00	1.43±0.00
21	KLM20	2.76±0.01	71.15±0.01	13.57±0.01	13.94±0.01	16.22±0.01	1.68±0.01	34.16±0.01	0.99±0.01	21.85±0.01	1.64±0.01
22	KLM26	2.12±0.01	69.52±0.01	14.97±0.01	13.57±0.01	15.82±0.01	1.49±0.01	30.51±0.01	1.26±0.01	21.39±0.01	1.49±0.01
23	KLM27	1.13±0.01	57.96±0.01	14.23±0.01	15.25±0.01	17.52±0.01	1.15±0.01	36.19±0.01	1.06±0.01	22.62±0.01	1.55±0.01
24	KLM28	1.84±0.01	70.58±0.01	9.95±0.01	13.51±0.01	19.22±0.01	1.50±0.01	29.63±0.01	1.03±0.01	19.98±0.01	1.55±0.01
25	KLM29	2.03±0.00	71.44±0.00	14.59±0.00	13.15±0.00	19.02±0.00	1.10±0.00	33.72±0.00	1.13±0.00	21.50±0.00	1.30±0.00
26	KLM31	1.44±0.01	64.51±0.01	9.84±0.01	11.27±0.01	16.82±0.01	1.02±0.01	43.57±0.01	1.02±0.01	20.77±0.01	1.17±0.01
27	KLM33	2.05±0.01	72.32±0.01	11.44±0.01	8.46±0.01	17.12±0.01	1.72±0.01	43.94±0.01	1.12±0.01	21.02±0.01	1.18±0.01
28	KLM35	2.81±0.00	64.98±0.00	8.81±0.00	11.44±0.00	16.02±0.00	1.33±0.00	31.92±0.00	1.20±0.00	22.21±0.00	1.28±0.00
29	KLM37	3.05±0.01	73.82±0.01	16.35±0.01	16.27±0.01	19.52±0.01	1.96±0.01	43.99±0.01	1.63±0.01	22.33±0.01	1.82±0.01
30	KLM38	2.33±0.01	71.50±0.01	12.74±0.01	12.23±0.01	19.32±0.01	1.24±0.01	38.00±0.01	1.14±0.01	22.64±0.01	1.47±0.01
31	KLM40	2.74±0.01	69.99±0.01	9.29±0.01	9.29±0.01	16.12±0.01	1.84±0.01	31.05±0.01	1.28±0.01	21.81±0.01	1.57±0.01
32	PTA01	2.55±0.01	66.41±0.01	8.46±0.01	12.17±0.01	17.02±0.01	1.66±0.01	39.09±0.01	1.13±0.01	20.71±0.01	1.52±0.01
33	TVM01	1.29±0.01	64.47±0.01	15.25±0.01	10.18±0.01	17.62±0.01	1.54±0.01	34.25±0.01	1.15±0.01	20.68±0.01	1.35±0.01
34	TVM02	2.86±0.01	62.17±0.01	13.51±0.01	14.67±0.01	18.42±0.01	1.43±0.01	42.28±0.01	1.18±0.01	20.28±0.01	1.13±0.01
35	Control	0.98±0.01	51.35±0.01	7.04±0.01	8.84±0.01	8.39±0.01	0.52±0.01	16.64±0.01	0.65±0.01	16.34±0.01	1.95±0.01

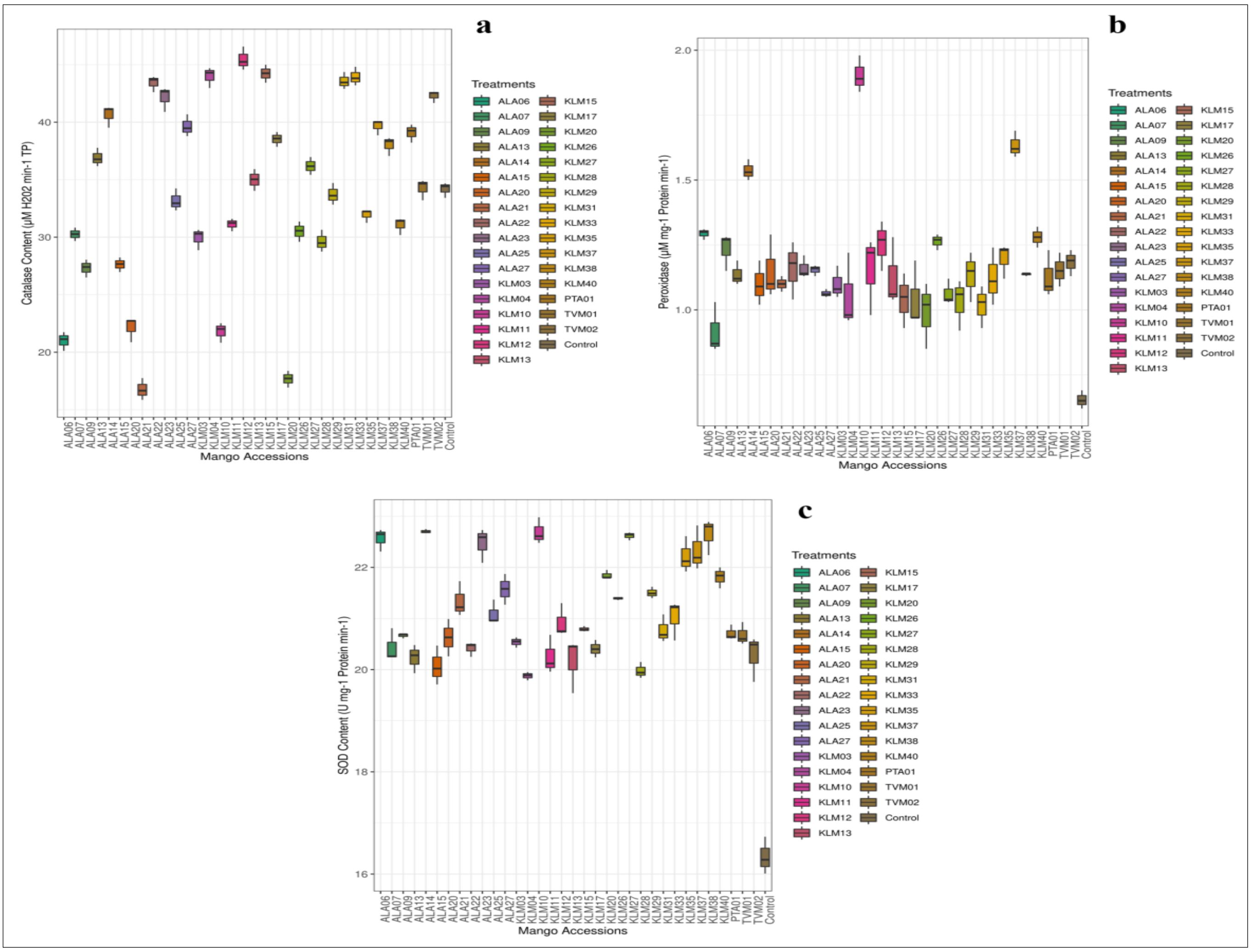

Fig. 3. (a) Catalase (b) Peroxidase and (c) Superoxide dismutase content in mango accessions.

Stress-induced changes in total chlorophyll content

The highest chlorophyll content under salt stress was observed in accession KLM10, with a mean of 1.94 mg g^{-1} FW (Fig. 1d, Table 2). Accessions such as ALA14 and ALA25 also showed relatively high chlorophyll contents of 1.72 and 1.69 mg g^{-1} FW, respectively, suggesting a good tolerance to salinity-induced oxidative stress.

Correlation of salinity tolerance index vs biochemical parameters

Among the accessions, KLM10 (Fig. 4a) which is collected from Kollam district, but in the border to Alappuzha district and near coastal area exhibited the highest mean tolerance index of 9.67 (Table 3), indicating minimal salinity stress symptoms, followed by ALA14 with a score of 9.00 and KLM26, KLM37 and ALA25, each with a score of 8.67. Conversely, ALA21 showed the lowest tolerance index of 1.00, reflecting severe stress symptoms. The control plants, as expected, maintained the highest tolerance index of 10.00, confirming the absence of stress symptoms.

There is a statistically significant moderate positive correlation between Total Phenol content and Tolerance Index (r^2 = +0.429, p = 0.010 significant at 5 df) (Fig. 4b) and Total Chlorophyll content and tolerance index (Fig. 4b) in the mango accessions studied, suggesting that higher phenol content and chlorophyll content is associated with better tolerance to salinity stress.

Discussion

All mango varieties had higher amounts of glycine betaine (GB) and proline when they were exposed to salt stress. This aligns with the concept that osmolytes facilitate osmotic adjustment in plants under salt stress, aiding in cellular protection and stress mitigation (11, 12). Studies have shown that proline accumulation under salt stress is linked with stress tolerance in many plant species (13). Compared to the other accessions, KLM10 had the most glycine betaine (GB) and proline accumulation, indicating its superior ability to reduce salinity stress.

Peroxidase has a crucial function in the removal of H_2O_2. It is also implicated in the process of growth and development (14). Accession KLM10, with the highest phenolic content, exhibited a robust non-enzymatic antioxidant response, potentially contributing to its superior tolerance to oxidative stress induced by salinity. The PPO enzyme is responsible for the oxidation of the phenolic compound and it also has an important role in the defence mechanisms of salt stress (15). Phenolic compounds are known for their antioxidant properties, which help in mitigating oxidative damage by scavenging ROS (16). Current study's positive correlation between phenolic content and salinity tolerance aligns with the results reported in other horticultural crops (17).

There have been earlier reports on the impact of salinity on catalase activity (18-20). By converting it to H_2O and O_2,

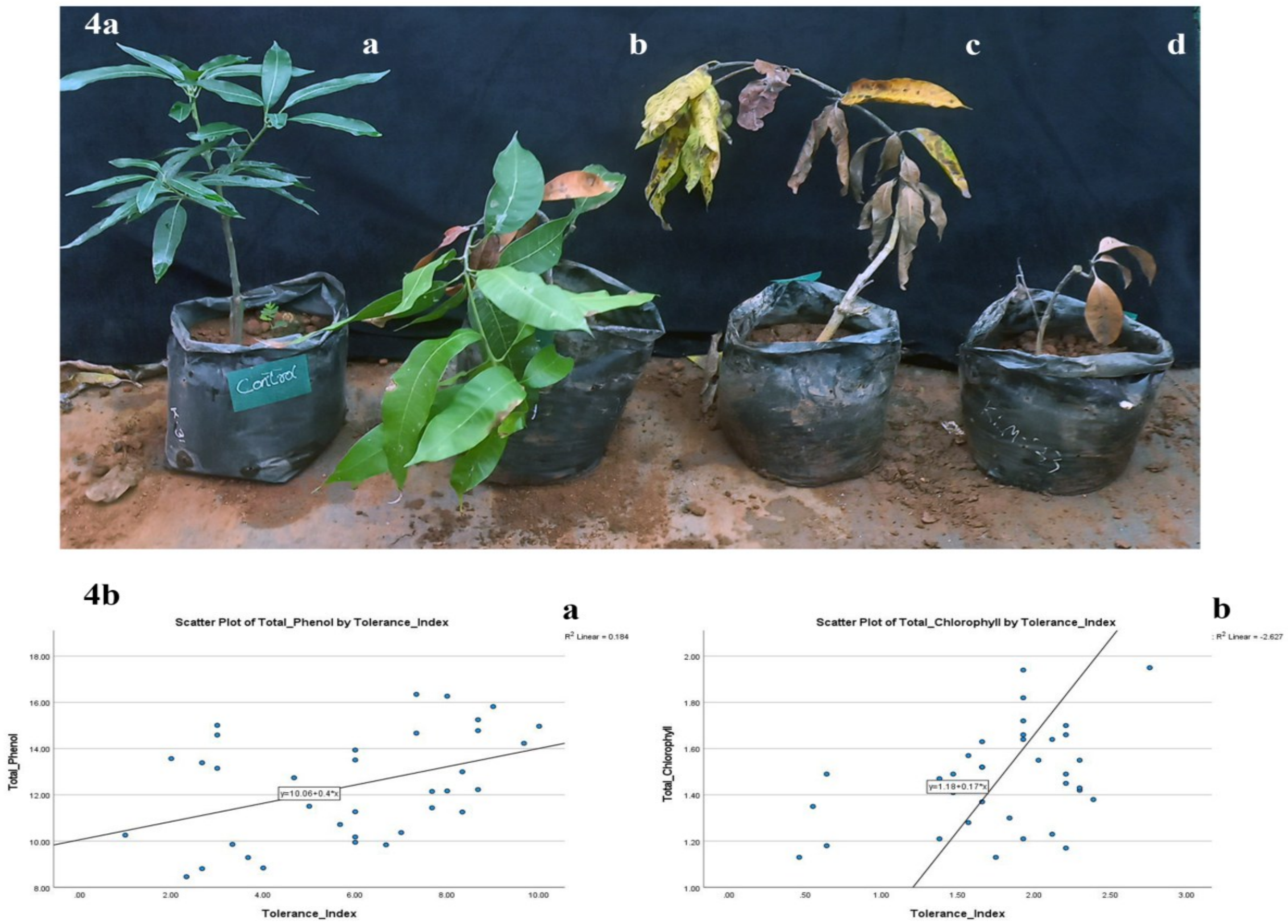

Fig. 4a. The morphological indications of saline stress on mango accessions were observed 60 days after stress induced. (a) Control (b) KLM 10 (c) KLM 13 and (d) KLM 33. **4b.** ANOVA analysis showing significant relation of tolerance index with (a) Total Phenol and (b) Total Chlorophyll.

Table 3. Estimates of salinity tolerance index of mango cultivars through stress symptoms evaluation

Accessions	Tolerance Index (TI)
ALA06	8.33
ALA07	2.67
ALA09	2.67
ALA13	7
ALA14	9
ALA15	5.67
ALA20	3.33
ALA21	1
ALA22	3
ALA23	6.67
ALA25	8.67
ALA27	8.33
KLM03	10
KLM04	6
KLM10	9.67
KLM11	7.33
KLM12	5
KLM13	4.67
KLM15	7.67
KLM17	3
KLM20	6
KLM26	2
KLM27	8.67
KLM28	6
KLM29	3
KLM31	6
KLM33	2.33
KLM35	7.67
KLM37	8
KLM38	8.67
KLM40	3.67
PTA01	8
TVM01	6
TVM02	7.33
Control	4

catalase eliminates H_2O_2 (21). Catalase and peroxidase activities were notably higher in accessions such as KLM10 and KLM37, indicating a strong enzymatic defence mechanism. According to the findings (22), the higher catalase activity in KLM12 and the elevated peroxidase activity in KLM10 are signs of their improved ability to deal with salinity-induced oxidative stress.

Accessions KLM10 and KLM37 maintained higher chlorophyll levels under salinity, suggesting better stress tolerance. Chlorophyll degradation is a common symptom of salinity stress, leading to reduced photosynthetic capacity and growth (23, 24).

The mango accessions' salinity tolerance index varied significantly, with KLM10 showing the highest tolerance and ALA14 and KLM26 following. The significant positive correlation between total phenol content and the tolerance index emphasizes the vital role of phenolic compounds in enhancing salinity tolerance. This finding is consistent with earlier reports that highlight the role of phenolics in strengthening plant defence mechanisms against abiotic stresses (25).

In conclusion, our study demonstrates that mango accessions exhibit a range of biochemical and physiological responses to salinity stress, with certain accessions like KLM 10, KLM 37 and ALA14 showing remarkable resilience. Increasing the production of secondary metabolites, osmolytes and enzymes is a key part of allowing plants to tolerate high salt levels. These findings provide valuable insights for breeding programmes aimed at developing salinity-tolerant mango varieties.

Conclusion

The study evaluated the abiotic stress tolerance of traditional mango varieties in South Kerala. It was found that significant increase in glycine betaine, proline and total soluble levels under salinity stress, with KLM10 exhibiting the highest GB content. The study also found enhanced non-enzymatic antioxidant production, tannin content and total phenol content under stress. The findings highlight the importance of conserving traditional mango varieties and utilizing their genetic diversity to develop salinity-tolerant cultivars. The present study revealed that the selected accessions (KLM10, KLM26, KLM37, ALA14, ALA06, ALA25 and ALA27) could be used for growing in saline tolerant areas.

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Authors' contributions

BB conceived and designed the study. BB and SS collected and assembled the data. SS performed the statistical analysis. BB and SS analysed and interpreted the data. SS drafted the manuscript. BB critically revised the manuscript for important intellectual content. BB secured the funding for the study. Both authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical issues: None

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