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Research Article

GROWTH PERORMANCE OF TAMARIND *(Tamarindus indica L.)* SEEDLINGS TO DIFFERENT LEVELS OF SALINITY AND SODICITY

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Abstract

Agroforestry is a viable land-use option of salt affected soils which ensure the remunerative use of this valuable resource. A two years pot study was carried out to evaluate salinity tolerance of tamarind fruit plant against different levels of salinity and sodicity. Treatments included were: T_1 = EC_e, 1.17 dS m^{-1} + SAR, 10.87, T_2 = EC_e, 6 dS m^{-1} + SAR, 25, T_3 = EC_e, 6 dS m^{-1} + SAR, 35, T_4 = EC_e, 6 dS m^{-1} + SAR, 45, T_5 = EC_e, 8 dS m^{-1} + SAR, 25, T_6 = EC_e, 8 dS m^{-1} + SAR, 35, T_7 = EC_e, 8 dS m^{-1} + SAR, 45, T_8 = EC_e, 10 dS m^{-1} + SAR, 25, T_9 = EC_e, 10 dS m^{-1} + SAR, 35, T_{10} = EC_e, 10 dS m^{-1} + SAR, 45. Results revealed that no plant was survived at higher level of salinity (10 dS m^{-1}) and sodicity (SAR 45) and complete cessation and mortality was observed in this treatment. Data of survived plants at the end of study showed that salinity and sodicity suppressed the growth variables of tamarind seedlings and increasing levels of salinity-sodicity led a reduction of 3.52% to 82.47% in plant height, 1.53% to 84.61% in stem girth, 5.63% to 88.26% in number of leaves and 7.44 to 90.77 in number of branches over control (non-stress) treatment. Therefore, it was concluded that tamarind seedling can withstand and survive at salinity and sodicity level of 10 dS m^{-1} and SAR 35.

Keywords: Fruit plant, Salinity, Sodicity, Tamarind, Tolerance.
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1. INTRODUCTION

Globally, soil salinity and sodicity have degraded one billion hectares of land (Dagar and Minhas, 2016). This salt induced land degradation under the impact of climate change has emerged a daunting environmental issue which continues to threaten agricultural productivity. Consequently, amelioration and productivity enhancement of salt induced degraded land is indispensable to fulfil the increasing demand of food, wood and fiber for growing population. Generally, degraded lands are possessed by small farmers facing poverty and severe unemployment. Therefore, rehabilitation of degraded land with use of chemical amendments may fail to deliver the expected dividends due to socioeconomic limitations of farming community (Gupta et al., 2013). Planting of salt tolerant tree species without accomplishing physical remediation is a viable and economical land use option for the rehabilitation of salt affected soil which provide a great opportunity for income generation and maintain soil health. However, limited scientific databases for the salinity tolerance potential of wide range of plant species especially fruit tree remains a challenge. To achieve maximum benefits and effective utilization of salt-affected land, a research-based knowledge for salinity/sodicity tolerances potential of different field crop is required so that this environmental burden transform into economic opportunities for the farming community. Several fruit trees, field crops, medicinal species, shrubs, bio-fuel crops and forages grasses have been identified having ability to withstand salinity and sodicity stress. Thus, management through crop diversification may be a promising option for economic utilization of marginally salt affected soil and to arrest further salt induced degradation of this valuable natural resource. Use of salt tolerant tree species is an alternative biological reclamation strategy which ensure remunerative and sustainable land use of salt-affected soil and control further deterioration and maintain soil health (Dagar et al., 2015). Salt affected soils get ameliorated by plant debris, leaf litter, organic carbon reduced exchangeable sodium percentage and pH (Sharma et al., 2010). A wide range of fruit and forest trees have been identified suitable for cultivation on salt-affected land (Dagar, 2014). In a long-term experiment of seven years, out of 30 tree species, Tamarix articulata, Acacia nilotica and Prosopis juliflora produced biomass of 93, 70 and 51 Mg ha-1, respectively and were found economically suitable for cultivation on alkali soil (Singh and Dagar, 2005). Glycyrrhiza glabra is promising salt tolerant species which rehabilitate large areas in the Hungry Steppes of Central Asia (Kushiev et al., 2005).

Tamarindus indica L. is a semi-evergreen, multipurpose fruit tree. It is cultivated more than 50 countries to meet local communities (El-Siddig et al., 2006). The species has wide use as environment decoration, forage for domestic animals, wood for construction, folk medicine and various food and non-food uses (Van der Stege et al., 2011; Bourou et al., 2012)). It is ideal to be cultivated in drought environment (Pereira et al., 2007) and salinity degraded areas (Hunsche et al., 2010; Hardikar and Pandey, 2011) of semiarid regions. Gebauer and Georg (2004) investigated the effect of saline water (0, 20, 40, 60 and 80 mM NaCl) on growth performance of four-week-old tamarind seedling grown in sand culture. Twenty weeks after irrigation with saline water they observed leaves injury symptoms in 60 and 80 mM NaCl. Dry weight, shoot height and leaf area decreased linearly with increasing levels of salinity and effects were more noticeable at 60 and 80 mM NaCl. Similarly, Neto et al. (2018) studied the growth variables of tamarind seedling irrigated with 0.5, 1.5, 3.0, 4.5, and 6.0 dS m-1. Increasing levels of saline water compromised growth parameters of tamarind seedling and higher intensity of saline water significantly reduced seedling biomass, leaf area, chlorophyll contents and carotenoids. Fatima et al. (2019) concluded that saline water irrigation with 2.15 dS m-1 caused an acceptable reduction of 10% in growth variables of tamarind plant while further increase in salinity i.e., 3.7 and 5.2 dS m-1 had detrimental effect on shoot height and stem diameter. Previously El-Siddig et al. (2004) exposed the tamarind seedlings to 0, 30, 60 and 120 mM NaCl solution. They reported that seedling growth was not markedly influence at 30 mM, however, 120 mM produced a strong inhibitory effect on seedling emergence, root/shoot fresh and dry weight. Hunsche et al. (2010) evaluated the effect of 0 (control), 40, 80, or 160 mM NaCl on salinity tolerance mechanisms of tamarind. They reported that Cl and Na contents increased, while chlorophyll content, Ca and antioxidative capacity reduced with rising NaCl concentration.

To our knowledge, effects of dual stress of salinity and sodicity on tamarind seedling are hardly investigated. Nevertheless, this information is very important for its domestication in saline-sodic areas. Keeping above facts in view, a pot study was designed to explore salinity-sodicity tolerance of tamarind seedling and to identify the level at which tamarind seedling can grow successfully in saline-sodic conditions.

2. MATERIALS AND METHODS

2.1. Experimental site and treatments detail

A pot study was executed from 2016 to 2018 at Soil Salinity Research Institute, Pindi Bhattian, Pakistan to explore the ability of tamarind seedling to withstand under different levels of salinity and sodicity stress. A normal soil was analyzed for (ECe = 1.17 dS m-1, SAR = 10.87, pHs = 7.56, Organic matter = 0.77 (%), Extractable K = 110.0 (mg kg-1) and Available P = 11.6 (mg kg-1) Texture = loam, Saturation percentage = 33.50. Desired levels of ECe and SAR were developed artificially using Na2SO4, NaCl, CaCl2 and MgSO4 as calculated with the help of quadratic equation (Ghafoor et aI., 1988). Treatments included were: T1 = ECe, 1.17 dS m-1 + SAR, 10.87, T2 = ECe, 6 dS m-1 + SAR, 25, T3 = ECe, 6 dS m-1 + SAR, 35, T4 = ECe, 6 dS m-1 + SAR, 45, T5 = ECe, 8 dS m-1 + SAR, 25, T6 = ECe, 8 dS m-1 + SAR, 35, T7 = ECe, 8 dS m-1 + SAR, 45, T8 = ECe, 10 dS m-1 + SAR, 25, T9 = ECe, 10 dS m-1 + SAR, 35, T10 = ECe, 10 dS m-1 + SAR, 45.

2.2. Experimental design and data recorded

After development of desired levels of salinity and sodicity, glazed pots were filled @ 15 kg soil per pot. Pots were arranged in Completely Randomized Design (CRD) with three replications. tamarind seedling with almost a uniform stature were planted on 11-10-2016 in these pots keeping one plant in each pot. Fertilizer @ one liter of 1% urea, triple super phosphate and sulphate of potash was applied at the start and after every six months. All agronomic and plant protection measures were exercised uniformly. Tamarind seedling could not survive in T10 (ECe 10 dS m-1 and SAR 45). While data of survived seedlings regarding growth characteristics i.e., plant height stem diameter, number of branches per plants and number of leaves per plant was recorded on 27-9-2017 and 02-10-2018. Leaves and roots Na and K contents were also determined using flame photometer (digiflame code DV 710) by adopting standard protocol. All plant and soil analysis were carried out following the methods of U.S. Salinity Laboratory Staff (1954).

2.3. Statistical Analysis

The collected data for various growth parameters were statistically analyzed. The treatment mean comparisons were made using Least Significant Difference Test @ 5% probability (Steel *et al.*, 1997) using STATISTIX 8.1 package software.

3. Results:

3.1. Plant height

Dual stress of salinity and sodicity negatively affected the growth of tamarind seedling and effect was more pronounced with increasing levels of salinity and sodicity, even plants could not survive in T10 (ECe 10 dS m-1 and SAR 45). Plant height was also suppressed with increasing levels of salt stress and data of second year showed that plant height was 125 cm in control (non-stressed) with maximum increase of 19 cm with respect to its initial value, while minimum increase of 3.33 cm was noted at higher levels of salinity and sodicity (ECe 10 dS m-1 and SAR 35) (Table 1). When we compared the salinity treatments with control (non-stressed), a reduction of 3.52%, 26.31%, 57.89%, 31.57%, 42.10%, 80.73%, 68.42%, 82.47% was recorded respectively in T2, T3, T4, T5, T6, T7, T8 and T9.

3.2. Stem girth

Stem girth was significantly ($p < 0.05$) suppressed by root zone salinity and salinity treatments were differentiated more clearly after two years (Table 2). The maximum increase of 0.65 cm was attained by plants in non-stressed conditions after the two years which decreased linearly with increasing levels of salinity and sodicity and minimum increase of 0.10 cm with respect to initial value was divulged in survived plants at the highest intensities of salinity and sodicity (ECe 10 dS m-1 and SAR 35). Dual stress of sodicity and salinity led to reduction of 1.53%, 15.38%, 47.69%, 30.76%, 52.30%, 72.30%, 66.15%, 84.61% in T2, T3, T4, T5, T6, T7, T8 and T9 as compared to control.

3.3. Number of leaves

Table 1: EFFECT OF DIFFERENT LEVELS OF EC_e AND SAR ON PLANT HEIGHT (cm) OF TAMARIND SEEDLINGS

Treatments EC: SAR	At transplantation	After one year	After two years	Increase in two years	Difference over control	Decrease over control
T_1 - Control	106.00 A	113.00 AB	125.00 AB	19.00	----	----
T_2 - (6 : 25)	114.67 A	120.67 A	133.00 A	18.33	0.67	3.52
T_3 - (6 : 35)	97.00 ABC	103.67 ABC	111.00 ABCD	14.00	5.00	26.31
T_4 - (6 : 45)	76.00 BCD	80.33 CD	84.00 DE	8.00	11.00	57.89
T_5 - (8 : 25)	105.00 AB	111.33 AB	118.00 ABC	13.00	6.00	31.57
T_6 - (8 : 35)	95.00 ABC	99.66 ABCD	106.00 ABCD	11.00	8.00	42.10
T_7 - (8 : 45)	73.00 CD	75.00 D	76.66 E	3.66	15.34	80.73
T_8 - (10 : 25)	99.00 ABC	102.33ABCD	105.00 BCD	6.00	13.00	68.42
T_9 - (10 : 35)	89.00 ABC	91.00 BCD	92.33 CDE	3.33	15.67	82.47
T_{10} - (10 :45)	58.33 D	Not survived	Not survived	----	----	----

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

Data regarding number of leaves depicted that dual stress of salinity and sodicity

Table 2: EFFECT OF DIFFERENT LEVELS OF EC_e AND SAR ON STEM GIRTH (cm) OF TAMARIND seedlings

Treatments EC: SAR	At transplantation	After one year	After two years	Increase in two years	Difference over control	Decrease over control
T_1 - Control	0.75 A	1.05 A	1.40 A	0.65	----	----
T_2 - (6 : 25)	0.72 A	1.03 A	1.36 AB	0.64	0.01	1.53
T_3 - (6 : 35)	0.75 A	1.02 A	1.30 AB	0.55	0.1	15.38
T_4 - (6 : 45)	0.63 AB	0.80 BC	0.97 CD	0.34	0.31	47.69
T_5 - (8 : 25)	0.72 A	0.95 AB	1.17 BC	0.45	0.2	30.76
T_6 - (8 : 35)	0.61 AB	0.77 BC	0.92 D	0.31	0.34	52.30
T_7 - (8 : 45)	0.50 BC	0.60 CD	0.68 EF	0.18	0.47	72.30
T_8 - (10 : 25)	0.67 A	0.79 BC	0.89 DE	0.22	0.43	66.15
T_9 - (10 : 35)	0.48 BC	0.54 D	0.58 F	0.10	0.55	84.61
T_{10} - (10 :45)	0.41 C	Not survived	Not survived	----	----	----

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

significantly ($p < 0.05$) arrested the growth of leaves and detrimental effect was more pronounced with age of plants and severity of stresses (Table 3). After two years, non-stressed seedlings produced maximum (419) number of leaves which decreased significantly and limited to only (166) leaves per plants in T9 (ECe 10 dS m-1 and SAR 35). Compared with control reduction of 5.63%, 21.83%, 42.60%, 27.81%, 54.22%, 70.07%, 69.71%, 88.26%, was recorded in T2, T3, T4, T5, T6, T7, T8 and T9 respectively at the end of study.

Table 3: EFFECT OF DIFFERENT LEVELS OF ECe AND SAR ON NUMBER OF LEAVES OF TAMARIND SEEDLINGS

Treatments EC: SAR	At transplantation	After one year	After two years	Increase in two years	Difference over control	Decrease over control
T1 - Control	135.00 AB	258.00 A	419.00 A	284.00	----	----
T2 - (6 : 25)	129.00 AB	247.00 A	397.00 AB	268.00	16.00	5.63
T3 - (6 : 35)	141.00 A	250.00 A	363.00 BC	222.00	62.00	21.83
T4 - (6 : 45)	118.00 AB	197.00 BC	281.00 D	163.00	121.00	42.60
T5 - (8 : 25)	136.00 AB	239.00 AB	341.00 C	205.00	79.00	27.81
T6 - (8 : 35)	115.00 AB	181.00 CD	245.00 DE	130.00	154.00	54.22
T7 - (8 : 45)	127.00 AB	172.00 CD	212.00 EF	85.00	199.00	70.07
T8 - (10 : 25)	107.00 AB	148.00 D	193.00 F	86.00	198.00	69.71
T9 - (10 : 35)	132.67 AB	148.00 D	166.00 F	33.33	250.67	88.26
T10 - (10 :45)	92.667 B	Not survived	Not survived	----	----	----

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

3.4. Number of branches

Salinity/sodicity also suppressed the number of branches of tamarind seedlings and detrimental effect was more visible at the end of study (Table 4). On average, unstressed (control) plants showed an increase of 18 branches per plants which dwindled to only 1.66 in T7 (ECe 8 dS m-1 and SAR 45). In comparison to control reduction of 7.44%, 38.88%, 68.55%, 11.11%, 59.27%, 90.77%, 62.94%, 87.05% was divulged in T2, T3, T4, T5, T6, T7, T8 and T9.

3.5. Leaves and root Na^+ contents

Ionic analysis at the end of study showed that leaves and roots Na^+ contents increased with rhizosphere salinity/sodicity and maximum Na^+ contents were observed at higher level of salinity and sodicity at T_9 (EC_e 10 dS m^{-1} and SAR 35). As compared to control Na^+ contents were increased by 194.73% and 50.0% in leaves and roots respectively in T_9 (Fig. 1 & 2).

3.6. Leaves and root K^+ contents

An inverse relation was observed between leaves and root K^+ contents and salinity/sodicity levels. K^+ uptake was suppressed by roots and leaves as salinity and sodicity increased in growth medium and particularly higher level of salinity and sodicity at (EC_e 10 dS m^{-1} and SAR 35) was detrimental for K^+ uptake and minimum contents of K^+ were observed in this treatment. A reduction of 55.55% and

Table 4: EFFECT OF DIFFERENT LEVELS OF EC_e AND SAR ON NUMBER OF BRANCHES OF TAMARIND SEEDLINGS

Treatments EC: SAR	At transplantation	After one year	After two years	Increase in two years	Difference over control	Decrease over control
T_1 - Control	11.00 ABC	18.66 AB	29.00 A	18.00	----	----
T_2 - (6 : 25)	10.00 ABCD	17.00 ABC	26.66 A	16.66	1.34	7.44
T_3 - (6 : 35)	8.33 BCD	13.00 CDE	19.33 B	11.00	7.00	38.88
T_4 - (6 : 45)	6.00 CD	8.66 EF	11.66 CD	5.66	12.34	68.55
T_5 - (8 : 25)	13.66 A	21.00 A	29.66 A	16.00	2.00	11.11
T_6 - (8 : 35)	8.33 BCD	11.66 DE	15.66 BC	7.33	10.67	59.27
T_7 - (8 : 45)	5.00 D	6.00 F	6.66 D	1.66	16.34	90.77
T_8 - (10 : 25)	11.66 AB	15.00 BCD	18.33 B	6.67	11.33	62.94
T_9 - (10 : 35)	8.33 BCD	9.66 EF	10.66 CD	2.33	15.67	87.05
T_{10} - (10 :45)	7.66 BCD	Not survived	Not survived	----	----	----

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

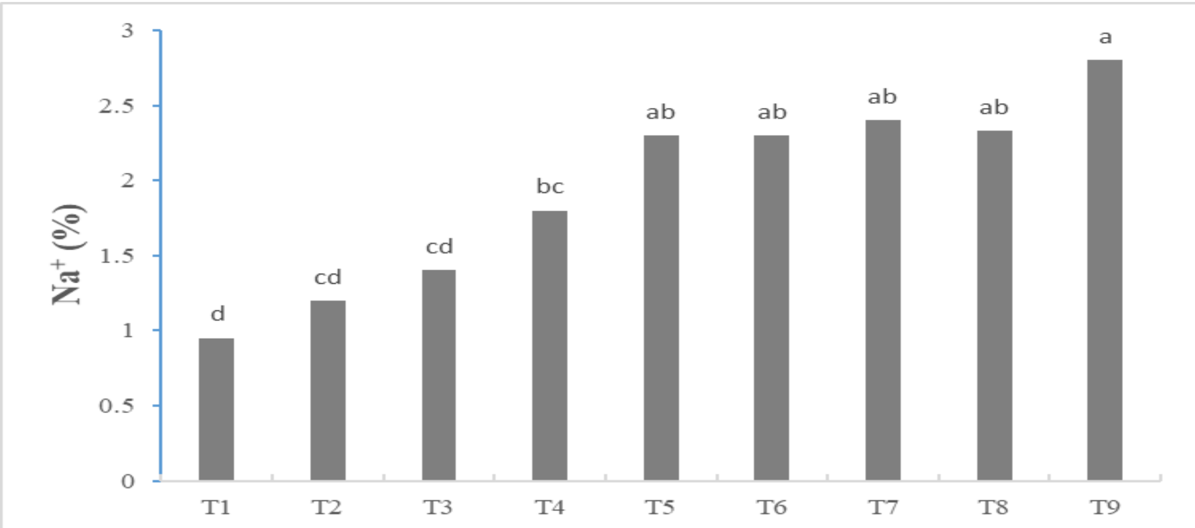

Fig 1. Effect of different levels of EC_e and SAR on leaves Na^+ (%) contents of tamarind seedlings at the end of study. T_1 (control), T_2 (EC_e 6 (dSm^{-1}) + SAR 25), T_3 (EC_e 6 (dSm^{-1}) + SAR 35), T_4 (EC_e 6 (dSm^{-1}) + SAR 45), T_5 (EC_e 8 (dSm^{-1}) + SAR 25), T_6 (EC_e 8 (dSm^{-1}) + SAR 35), T_7 (EC_e 8 (dSm^{-1}) + SAR 45), T_8 (EC_e 10 (dSm^{-1}) + SAR 25), T_9 (EC_e 10 (dSm^{-1}) + SAR 35)

28.57% was recorded in leaves and root K^+ respectively in comparison to control in T_9 (Fig. 3 & 4).

4. Discussion

In the era of climate change world is encountered with environmental and economic crisis. Loss of production capacity and degradation of natural resources through salinization is a more serious environmental problem and is needed to fight against, as it continues to threaten sustainability of agricultural

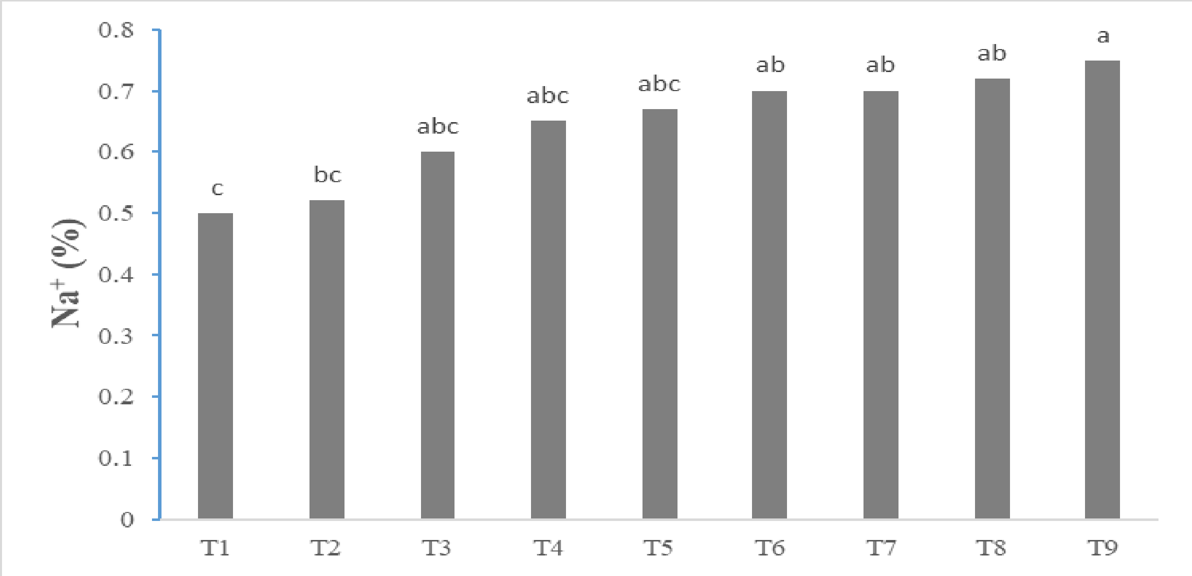

Fig 2. Effect of different levels of EC_e and SAR on roots Na^+ (%) contents of tamarind seedlings at the end of study. T_1 (control), T_2 (EC_e 6 (dSm^{-1}) + SAR 25), T_3 (EC_e 6 (dSm^{-1}) + SAR 35), T_4 (EC_e 6 (dSm^{-1}) + SAR 45), T_5 (EC_e 8 (dSm^{-1}) + SAR 25), T_6 (EC_e 8 (dSm^{-1}) + SAR 35), T_7 (EC_e 8 (dSm^{-1}) + SAR 45), T_8 (EC_e 10 (dSm^{-1}) + SAR 25), T_9 (EC_e 10 (dSm^{-1}) + SAR 35)

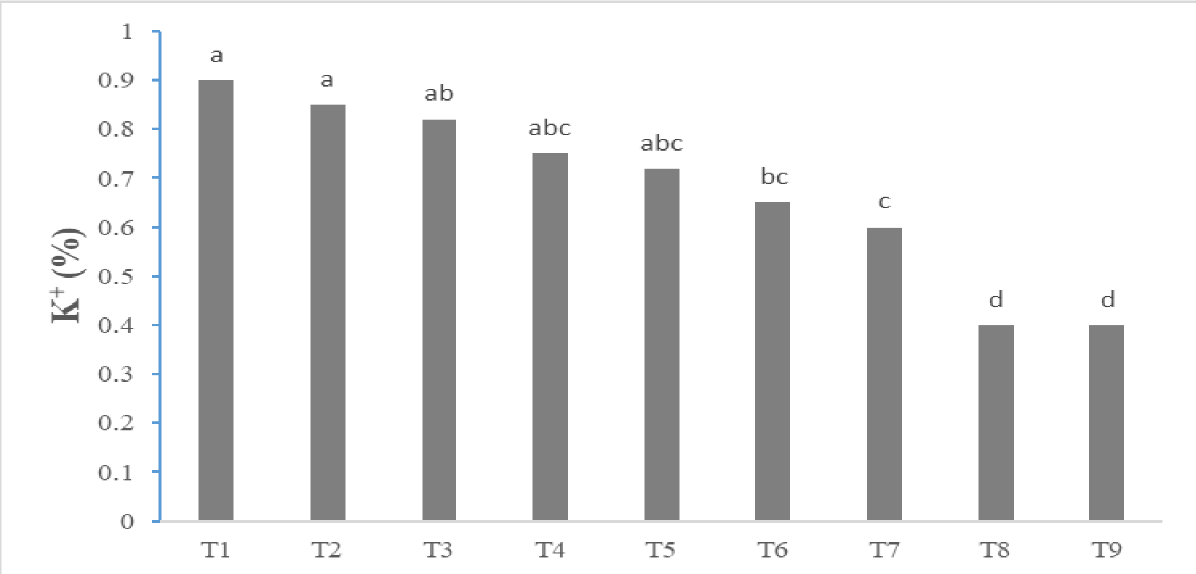

Fig 3. Effect of different levels of EC_e and SAR on leaves K^+ (%) contents of tamarind seedlings at the end of study. T_1 (control), T_2 (EC_e 6 (dSm^{-1}) + SAR 25), T_3 (EC_e 6 (dSm^{-1}) + SAR 35), T_4 (EC_e 6 (dSm^{-1}) + SAR 45), T_5 (EC_e 8 (dSm^{-1}) + SAR 25), T_6 (EC_e 8 (dSm^{-1}) + SAR 35), T_7 (EC_e 8 (dSm^{-1}) + SAR 45), T_8 (EC_e 10 (dSm^{-1}) + SAR 25), T_9 (EC_e 10 (dSm^{-1}) + SAR 35)

productivity and causes annual global income loss. Therefore, this situation demands research-based comprehensive approach which provide insight into different aspects of salt affected soils. Saline agriculture is expected to play a key role to achieve maximum benefits and sustainability of salt-affected soil. Research on the salinity tolerance potential of fruit plants is modest as compared to other agronomical crops because there is general perception that fruit crops are sensitive to salinity, however, some fruit crops may perform well under the salt stress. Therefore, current study was aimed to find out the ability of tamarind seedling to

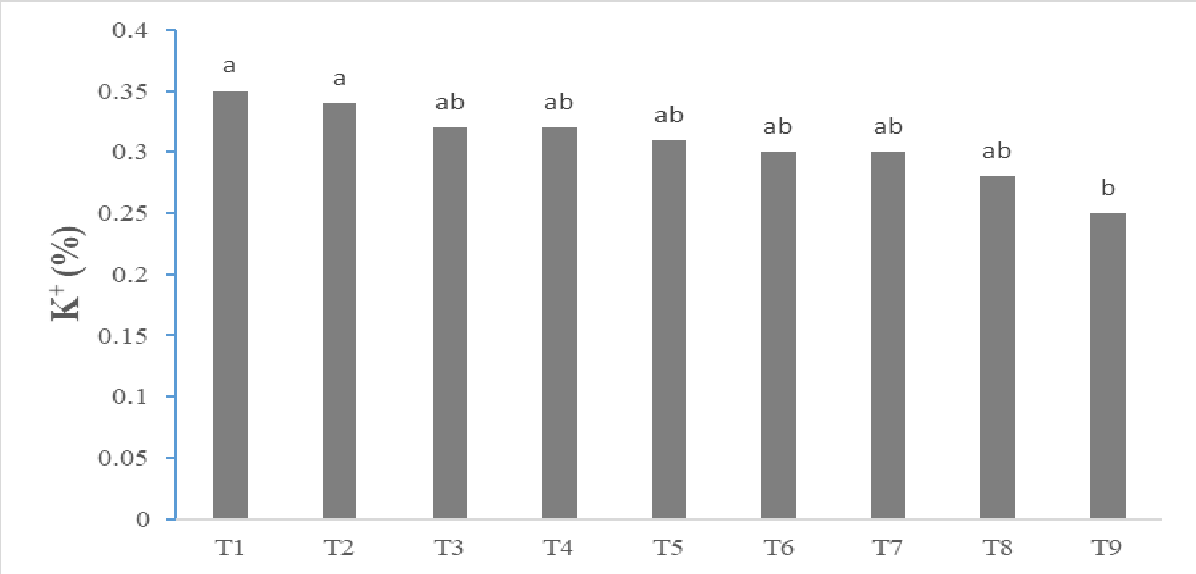

Fig 4. Effect of different levels of EC_e and SAR on root K^+ (%) contents of tamarind seedlings at the end of study. T_1 (control), T_2 (EC_e 6 (dSm^{-1}) + SAR 25), T_3 (EC_e 6 (dSm^{-1}) + SAR 35), T_4 (EC_e 6 (dSm^{-1}) + SAR 45), T_5 (EC_e 8 (dSm^{-1}) + SAR 25), T_6 (EC_e 8 (dSm^{-1}) + SAR 35), T_7 (EC_e 8 (dSm^{-1}) + SAR 45), T_8 (EC_e 10 (dSm^{-1}) + SAR 25), T_9 (EC_e 10 (dSm^{-1}) + SAR 35)

withstand under different levels of salinity (1.17, 6, and 8, 10 dS m-1) and sodicity (10.87, 25, 35, 45 SAR). Results of study exhibited progressively stronger inhibitory effects on most of the investigated traits of tamarind seedlings, even mortality was observed at higher level of salinity and sodicity (ECe 10 dS m-1 and SAR 45) in T10. Data of second year showed that dual stress of salinity and sodicity led a reduction of 3.52% to 82.47% in plant height, 1.53% to 84.61% in stem girth, 5.63% to 88.26% in number of leaves and 7.44 to 90.77 in number of branches over control (non-stress) treatment. Growth of most of most of fruit crop is suppressed by salinity > 2 dS m-1 and significant reduction may occur at 5 dS m-1 (Ebert, 2000). Similar results were observed in current study that complete mortality of tamarind seedlings occur at (ECe 10 dS m-1 and SAR 45). Gebauer and Georg (2004) also reported that increasing level of 80 mM NaCl stress caused a significant reduction in leaf area and plant height of tamarind seedlings. The depressing effect of salt stress on growth variables of tamarind seedlings may be justified by that continuous exposure of plants to abiotic stress alters the normal functioning of physiological and biochemical processes (Misra, 2018). The first effect of salt stress on plant is a quick shock of osmotic stress, resulting in drought conditions because roots are unable to absorb soil water (Munns and Tester, 2008). Most of the fruit plants are sensitive to this initial osmotic shock (Bernstein, 1980). Further, long term exposure of plants to salt stress environment as in current study results the accumulation of toxic ions in young leaves (Acosta-Motos et al., 2017) that suppress the plants growth and reduces fresh and dry weight of stem, leaves and root weight (Li and Li, 2017). Salt stress has been found to alter the leaf morphology, stimulates the falling and aging of older leaves (Li and Li, 2017) and reduces stem girth due to shrinkage of vascular tissues (Wungrampha et al., 2018). Conformity results were stated by Neto et al. (2018) that higher intensity of saline water significantly reduced seedling biomass, leaf area and chlorophyll contents in tamarind.

Salt stress inflicts detrimental effects on photosynthesis, reduced stomatal conductance and carbon assimilation which are directly related to low plant yield (Jajoo, 2014; Acosta- Motos et al., 2017). Root zone salinity leads to disruption of cell metabolism, enzyme structure and membrane integrity (Tanveer et al., 2018) thus decreases photosynthesis, respiration and ultimately crop yield (Wungrampha et al., 2018). In addition, excessive uptake of Na+ and Cl− caused ion toxicity in salt stressed plants which further hinders the uptake of essential nutrients like, N, P, K, Ca, and Mn (Nongpiur et al., 2016). Moreover, excessive uptake of Cl- and Na+ trigger K+ efflux, (Shabala, 2009) reduce leaf turgor potential (Chartzoulakis, 2005) generate reactive oxygen species (Misra, 2006) degrade the chlorophyl contents (Singh et al., 2015) limits the stomatal conductance (Flexas et al., 2004) reduce CO2 supply (Munns et al., 2006) resulting in low carbon fixation (Hniličková et al., 2019). All these factors have damaging effects on physiological and biochemical processes of plants and consequently, salt stressed plants show poor performance (Hasanuzzaman et al., 2013). Similarly, Fatima et al. (2019) concluded that salinity levels of 3.7 and 5.2 dS m-1 had detrimental effect on shoot height and stem diameter of tamarind plants which support the current findings.

5. Conclusion

Rehabilitation of salt prone land is not always economical and practicable approach because of environmental and socioeconomic constrains. Growing salt tolerant fruit plants may be a viable alternative approach which ensure the remunerative use of salt affected land. Therefore, above findings suggest that tamarind seedling can be grown successfully at salinity and sodicity level of 10 dS m-1 and SAR 35. However, it is recommended that results obtained in current study should investigated in detail under saline-sodic field conditions.

6. REFERENCES

Acosta-Motos, J. R., M. F. Ortuno, A. Bernal-Vicente, P. Diaz-Vivancos, M. J. Sanchez-Blanco and J. A. Hernandez. 2017. Plant responses to salt stress: adaptive mechanisms. Agronomy 7: 18.

Bernstein, L. 1980. Salt tolerance of fruit crops. USDA Agricultural Information Bulletin 292; United States Department of Agriculture, 1980; pp 8.

Bourou, S., C. Bowe, M. Diouf and Van Damme. 2012. Ecological and human impacts on stand density and distribution of tamarind (Tamarindus indica L.) in Senegal. Afri. J. Ecology, 50: 253-265.

Chartzoulakis, K.S. 2005. Salinity and Olive: Growth, Salt Tolerance, Photosynthesis and Yield. Agric. Water Manage. 78, 108-121.

Dagar, J.C. and P.S. Minhas. 2016. Global Perspectives on Agroforestry for the Management of Salt affected Soils. J.C. Dagar, P.S. Minhas (eds.), Agroforestry for the Management of Waterlogged Saline Soils and Poor-quality Waters, Advances in Agroforestry 13, DOI 10.1007/978-81-322-2659-8_2.

Dagar, J.C., C.B. Pandey and C.S. Chaturvedi. 2014. Agroforestry: a way forward for sustaining fragile coastal and island agro-ecosystems. In: Dagar JC, Singh AK, Arunachalam A (eds) Agroforestry systems in India: livelihood security & environmental services, vol 10, Advances in agroforestry. Springer, New Delhi, pp 185–232.

Dagar, J.C., R.K. Yadav, S.R. Dar and A. Sharif. 2015. Liquorice (Glycyrrhiza glabra): A potential salt tolerant highly remunerative medicinal crop which also helps in remediation of alkali soils. Curr. Sci. 108(9):1683-1688.

Ebert, G. 2000. Salinity problems in (Sub-) tropical fruit production. Acta Hortic. 531, 99-106.

El-Siddig, K., H. Gunasena, B. Prasad, D. Pushpakumara, K. Ramana, P. Vijayanand and J. Williams 2006. Tamarind, Tamarindus indica L.

Fruits for the future 1. CUC - Southampton Centre for Underutilised Crops, Southampton, UK.
El-Siddig, K., J. Gebauer, G. Ebert, A.M. Ali and S. Inanaga. 2004. Influence of salinity on emergence and early seedling growth of Tamarindus indica L. Eur. J. Hortic. Sci., 69(2): 79-81.
Fatima, R.T., M.L. Silva, J.S. Nobrega and R.G. Nobre. 2019. Effect of nitrogen fertilization on the growth and quality of tamarind seedlings irrigated with saline water. J. Exp. Agri. Int. 37(5): 1-12.
Flexas, J. J. Bota, F. Loreto, G. Cornic and T. D. Sharkey. 2004. Diffusive and metabolic limitations to photosynthesis under drought and salinity in c3 plants. Plant Biol. 6: 269-279.
Gebauer, J., K. El-Siddig, A.A. Salihc, G. Ebert. 2004. Tamarindus indica L. seedlings are moderately salt tolerant when exposed to NaCl-induced salinity. Scientia Horti. 103: 1-8.
Ghafoor, A., T. Aziz and M., Abdullah. 1988. Dissolution of gypsum size grades in synthetic saline solutions. J. Agri. Res. (26): 289-294.
Gupta, S.K. 2013. Subsurface Drainage for Waterlogged Saline Soils. Unpublished Report Submitted to Agricultural Education Division, ICAR, New Delhi; Central Soil Salinity Research Institute: Karnal, 2013; p 353.
Hardikar, S.A. and A.N. Pandey. 2011. Growth, water status, and nutrient accumulation of seedlings of Tamarindus indica Linn. in response to soil salinity. Commun. Soil Sci. Plant Analysis, 42(14): 1675-1691.
Hasanuzzaman, M., K. Nahar, and M. Fujita. 2013. Plant Response to Salt Stress and Role of Exogenous Protectants to Mitigate Salt-induced Damages. In: P. Ahmad, M. Azooz, and M.Prasad (eds.), Ecophysiology and Responses of Plants under Salt Stress., New York, NY: Springer.
Hniličková, H., F. Hnilička, M. Orsák and V. Hejnák. 2019. Effect of salt stress on growth, electrolyte leakage, Na+ and K+ content in selected plant species. Plant Soil Environ., 65: 90-96.
Hunsche, M., K. Bürling, A.S. Saied, M. Schmitz-Eiberger, M. Sohail, J. Gebauer, G. Noga and A. Buerkert. 2010. Effects of NaCl on surface properties, chlorophyll fluorescence and light remission, and cellular compounds of Grewia tenax (Forssk.) Fiori and Tamarindus indica L. leaves. Plant Growth Regulation, Berlin, 61(3): 253-263.
Jajoo, A. 2014. Changes in photosystem II heterogeneity in response to high salt stress. In: Contemporary Problems of Photosynthesis, ed. S. I. Allakhverdiev, A. B. Rubin and V. A. Shuvalov, Institute of Computer Science, Izhevsk, Moscow, pp. 397-413.
Kushiev, H., A.D. Noble, I. Abdullaev and U. Toshbekov. 2005. Remediation of abandoned saline soils using Glycyrrhiza glabra: a study from the Hungry steppes of central Asia. Int. J. Agric. Sustain., 3(2):102-112.
Li, W. and Q. Li. 2017. Effect of environmental salt stress on plants and the molecular mechanism of salt stress tolerance. Int. J. Environ. Sci. Nat. Res. 7.
Misra, A. N. 2018. Chlorophyll fluorescence: A practical approach to study ecophysiology of green plants. In: Advances in Plant Ecophysiology Techniques. ed. A. M. Sanchez-Moreiras and M. J. Reigosa, Springer International Publishing AG, part of Springer Nature, pp. 77–97.
Misra, N. and A. K Gupta. 2006. Effect of salinity and different nitrogen

sources on the activity of antioxidant enzymes and indole alkaloid content in Catharanthus roseus seedlings. J. Plant Physiol. 163, 11-18.
Munns, R. and M. Tester. 2008. Mechanisms of salinity tolerance. Ann. Rev. Plant Biol. 59: 651–681.
Munns, R., R.A. James and A. Läuchli, 2006. Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot. 57: 1025-1043.
Neto, A.J, L.F. Cavalcante, J.C. Nunes, A.G. Souto, F.T. Bezerra and A.G. Cavalcante. 2018. Biometric variables and photosynthetic pigments in tamarind seedlings irrigated with saline water and biofertilizers. Semina Ciências Agrárias, 39: 1909-1920.
Nongpiur, R.C., S.L. Singla-Pareek and A. Pareek. 2016. Genomics approaches for improving salinity stress tolerance in crop plants. Curr. Genomics 17: 343-357.
Pereira, P., B. Melo, A. Frazao and P. Alves. 2007. A cultura do tamarindeiro (Tamarindus indica L.). 2007. Acesso em, 26: 8-13.
Shabala, S. 2009. Salinity and programmed cell death: unraveling mechanisms for ion specific signaling. J. Exp. Bot. 60: 709-712.
Sharma, S.K., J.C. Dagar and S. Gurbachan. 2010. BIOSAFOR: biosaline (Agro) forestry: remediation of saline wastelands through production of renewable energy, biomaterial and fodder. Technical bulletin no. 4/2010. Central Soil Salinity Research Institute, Karnal, p 26.
Singh, A. P. C. Sharma, A. Kumar, M. D. Meena, D. K. Sharma, 2015. Salinity induced changes in chlorophyll pigments and ionic relations in bael (Aegle marmelos Correa) Cultivars. J. Soil Salin. Water Qual. 7, 40-44.
Singh, G. and J.C. Dagar. 2005. Greening sodic soils: Bichhian model. Technical bulletin no. 2/2005. Central Soil Salinity Research Institute, Karnal, p 51.
Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistic: A Biometrical Approach. Mc Graw Hill book Co. Inc. New York. 3rd edition, pp. 400-428.
Tanveer, M., B. Shahzad, A. Sharma, S. Biju and R. Bhardwaj. 2018. 24-Epibrassinolide; an active brassinolide and its role in salt stress tolerance in plants: A review. Plant Physiol. Biochem. 130: 69-79.
U.S. Salinity Lab. Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook 60, Washington DC, USA.
Van der Stege, C., S. Prehsler, A. Hartl and R. Vogl.2011. Tamarind (Tamarindus indica L.) in the traditional West African diet: not just a famine food. Fruits 66: 171-185.
Wungrampha, S., R. Joshi, S.L. Singla-Pareek and A. Pareek. 2018. Photosynthesis and salinity: are these mutually exclusive? Photosynthetica, 56: 366-381.