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RESEARCH ARTICLE

Influence of Saline Water on the Growth of Chiku (*Achras Zapota* L.) Saplings

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Abstract

Salinity and brackish water is very common problem in Pakistan due to partial rainfall, more evapo-transpiration and high temperature. So, there is need to select salt tolerant plants. In view of that a pot experiment was conducted to see the growth performance of chiku (*Achras zapota* L.) saplings under irrigation of different combinations of artificially developed saline – sodic water. Ten combinations of saline- sodic water treatments i.e. (T_1=<4(dSm^{-1}) + <13(mmol L^{-1})$^{1/2}$, T_2= 8(dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_3= 8(dSm^{-1}) + 25(mmol L^{-1})$^{1/2}$, T_4= 8 (dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$, T_5= 12 (dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_6= 12(dSm^{-1}) + 25 (mmol L^{-1})$^{1/2}$, T_7= 12(dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$, T_8= 16(dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_9= 16 (dSm^{-1}) + 25(mmol L^{-1})$^{1/2}$ and T_{10}= 16 (dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$) were evaluated in order to assess their effect on plant growth. Plant height was the highest (121cm) at the time of transplanting at lowest salinity and sodicity stresses i.e. T_1. After one year of transplanting this value was increased to132 cm presenting 9.09% increase over control after one year. T_{10} being the highest level of salinity plus sodicity got the bottom position (3.74%) in plant height. % increase over control after one year transplanting in stem diameter cleared the picture indicated the range i.e. 32.84 to 6.78 among treatments. % increase over control was decreased as well as the salinity cum sodicity toxicity was increased.

Keywords: Chiku (*Achras zapota* L.); Saline Water; EC plus SAR Levels; Growth; Sapling

Introduction

Chiku (*Achras zapota* L.) is an imperative fruit tree of *Sapotaceae* family of Mexico and Brazil [1]. Different growth stages of Chiku species showed deviation for salt tolerance. Some plant species depicted salinity tolerant at later growth stages and salinity sensitiveness at initial growth stages. Salinity tolerance variations established among many fruit tree species as mentioned in mango, guava, date palm and jujube [2-5]. Salt stress in fruit plants causes premature leaf drop, shoot dieback, leaf burning, blackening and necroses [6]. In Pakistan shortage of canal water is a foremost concern, especially in coastal region because of brackish groundwater, high temperature and seawater intrusion. Permanent brackish groundwater irrigation without a proper management damages fruitful gardens [7].

Salt-tolerance selected crop species were studied; cereals, oil seeds, fiber crops, vegetables, medicinal plants, sugar crops and fruit trees; mango, palm, guava, avocado and chiku too. Salinity limits of irrigation waters also appeares [8-17]. Species, climatic situation and growth stage influence plant salt-tolerance. Ashraf and Sarwar (2002) in their experiment reported that brackish water application decreased growth traits (plant height, number of leaves per plant, number of branches per plant and stem girth) and also observed that chiku plant survived in saline water [18]. Found that seedlings irrigated with 12 ECi (dS m^{-1}) water had maximum Na^+ and less K^+ proves Na^+ toxicity and K^+ deficiency with brackish water. High sodium concentration is cytotoxic for plants growth and development at saline environment [14,19]. Saline condition declines the enzymes activity with K^+ concentration reduction in turn affects enzyme activation because K^+ is essential for plant growth [20-22].

Salinity is a chief abiotic stress decreases crop production mainly in arid and semi-arid regions because having high soil salt content and deficient rainfall for salt leaching. Fruit crops are commonly salinity plus sodicity sensitive mostly in arid and semi-arid environments [23-25].

Plant growth is related with water stress, nutritional imbalance, salt stress or both with saline toxicity. Salinization harmful impacts managed with appropriate farm management practices [24,26].

Salinity sensitivity depends to the fruit plants morphology particularly in avocado trees having quite superficial root system with low consequence, therefore plummeting the water and nutrient absorption capacity [27]. Halophytes may also categorize naturally plants that endure salt but normally like saline environment [28]. Rengasamy (2006) reported that the extent of the problem can be estimated by primary salinity (natural saline soils) more than 100 countries while secondary salinity (irrigation-induced salinization) is increasing with more important food producing regions [29]. Presently, water logging and salinity gained shocking extent in numerous world irrigated regions [30]. Recently, secondary salinization credited to the persistent vegetation replacement with annual crops significantly increased mostly with rain fed areas [31]. Salinity caused losses (~US $12 billion) in agricultural production due to the non- adaptation of reclamation technologies that are anticipated to significantly increase in the following decades [32].

The excess soluble salts present in the saline soils- mainly chlorides and sulphates of Na^+, Ca^{2+} and Mg^{2+} raise the soil saturation extract electrical conductivity (ECe > 4 dS m^{-1}). Sodic soils, on the contrary, have variable ECe, exchangeable sodium percentage (ESP) above 15 and soil saturation extract pH (pHs) above 8.2. These soils also face surface crusting, hard setting, water accumulation and oxygen deficiency [31,33] . High RSC (residual sodium carbonate) plus high SAR (sodium adsorption ratio) - water hinders reclamation and exacerbates the salt stress for crops [34]. Mounting incomes and globalization also caused a 'nutritional evolution' with a clear dietary swing towards protein and calorie rich diets and health in recent times [35,36]. Salt stressed plants reveal electrolyte leakage and lipid peroxidation that undermine the cell membranes [37]. Salinity triggers undue accretion of hasty oxygen species such as superoxide radicals (O^{-2}) and hydrogen peroxide (H_2O_2) that dislocate the cell functions by causing oxidative damage to cell membranes and organelles, enzymes, photosynthetic pigments, lipids, proteins and nucleic acids [38]. Under saline conditions, most of the fruit species show adjustment in water relations [39]. Salinity diminished leaf chlorophyll with decayed cellular membranes and speeding up chlorophylls enzyme activity [40]. Photosynthetic assimilation decreased due to surfeit Na^+ and Cl^- ions in the leaf tissue [41].

Fruit plants counter numerous ways to reduce the effect of these adverse changes on cell structure and functions. Varioud antioxidant molecules (e.g., superoxide dismutase, catalase and ascorbate peroxidise) are activated to surmount the injurious free radicals [42]. To assuage the osmotic stress and cellular dehydration proline is synthesized [43]. The excess Na^+ and Cl^- ions show discrepancy response in fruit species. The toxic salinity effects are mostly owing to Cl^- ions addition in leaf and shoot tissue of citrus. Leaf abscission ensuing when leaf Cl^- concentration reaches around 1.5% (on dry weight basis) and ethylene production is triggered. Therefore, salt tolerance in many citrus species depends on ability of roots to prevent and/or reduce Cl^- uptake from the growing medium [44]. Keeping in view the above mentioned conditions a pot study was conducted to evaluate the growth chiku (*Achras zapota* L.) saplings with irrigation of different levels of saline water.

Materials and Methods

A pot study was conducted to evaluate the growth chiku (*Achras zapota* L.) saplings with irrigation of different levels of saline water at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2016-17. The soil used for the pot experiment was analysed and having 7.15 pHs, 2.10 ECe (dSm^{-1}), 4.32 SAR (mmol $L^{-1})^{1/2}$, 21.72 Saturation Percentage (%), 0.40 O.M. (%), 7.04 Available P (mg Kg^{-1}) and 93.14 Extractable K (mg Kg^{-1}). Different levels of artificial saline- sodic water were developed with salts of NaCl, $Na_2 SO_4$, $CaCl_2$ and $MgSO_4$ using Quadratic Equation.10 Kg soil was used to fill each pot. Four saplings of chiku (*Achras zapota* L) were sown in each pot. Fertilizer was applied @70-60-50 NPK Kg ha^{-1}. Ten combinations of saline- sodic water treatments i.e. (T_1=<4(dSm^{-1}) + <13(mmol $L^{-1})^{1/2}$, T_2= 8(dSm^{-1}) + 20(mmol $L^{-1})^{1/2}$, T_3= 8(dSm^{-1}) + 25(mmol $L^{-1})^{1/2}$, T_4= 8 (dSm^{-1}) + 30(mmol $L^{-1})^{1/2}$, T_5= 12 (dSm^{-1}) + 20(mmol $L^{-1})^{1/2}$, T_6= 12(dSm^{-1}) + 25 (mmol $L^{-1})^{1/2}$, T_7= 12(dSm^{-1}) + 30(mmol $L^{-1})^{1/2}$, T_8= 16(dSm^{-1}) + 20(mmol $L^{-1})^{1/2}$, T_9= 16 (dSm^{-1}) + 25(mmol $L^{-1})^{1/2}$ and T_{10}= 16 (dSm^{-1}) + 30(mmol $L^{-1})^{1/2}$) were evaluated in order to assess their effect on plant growth. Completely randomized deign was applied with three repeats. Data on plant height and stem diameter at the time of transplanting and after one year transplanting were collected.

Results and Discussions

Brackish water reduced the growth of *Achras zapota* L. seedlings (Table 1). Plant height is the main growth factor of this plant to resist against saline stress. Plant height was the highest (121cm) at the time of transplanting at lowest salinity and sodicity stresses i.e. T_1. After one year of transplanting this value was increased to132 cm presenting 9.09% increase over control after one year. T_{10} being the highest level of salinity plus sodicity got the bottom position (3.74%) in plant height. Therefore it is resulted that plant height is inversely proportional to salinity plus sodicity. Ashraf and Sarwar (2002) findings are in accordance with these results on branches, leaves and stem girth. Significant anatomical characteristics which plays an important role in salt tolerance include stomata shape, size, density and orientation, increased thickness (succulence) in leaf, root and stem, increased vascular bundle area, high water use efficiency, low transpiration rate, and low reduction in photosynthetic rate and chlorophyll pigments [18,45-47].

Stem diameter is the detrimental parameter in the growth of woody plants. Data regarding stem diameter presented in Table1 influenced the severity of salinity and sodicity stresses. % increase over control after one year transplanting cleared the picture indicated the range i.e. 32.84 to 6.78 among treatments. % increase over control was decreased as well as the salinity cum sodicity toxicity was increased. Salinity is a mainly decipherable abiotic stress that affects plant growth and confines the many physiological processes such as photosynthetic rate, mineral distribution and membrane permeability [48]. Different plants retort to salinity in different ways such as changes water balance and its uptake, transpiration, metabolic pathways, exchange of gases, leaves optical properties, ion uptake, respiration and photosynthesis, morpho-anatomical characteristics and balance of hormones (Table 1) [49-51].

Treatment	Plant height (cm) at transplanting	Plant height (cm) after 1year	% increase over initial value(after 1year)	Stem diameter (cm) at transplanting	Stem diameter (cm) after one year	% increase over initial value(after one year)
T_1	121	132	9.09	134	178	32.84
T_2	92	100	8.70	117	149	23.35
T_3	109	118	8.26	131	166	26.72
T_4	90	97	7.78	134	166	23.88
T_5	118	128	8.47	130	163	25.38
T_6	109	117	7.34	115	144	25.22
T_7	119	126	5.88	132	159	20.42
T_8	104	111	6.73	125	150	20.00
T_9	113	118	4.42	128	146	14.06
T_{10}	107	111	3.74	118	126	6.78

T_1=<4(dSm^{-1}) + <13(mmol L^{-1})$^{1/2}$, T_2= 8(dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_3= 8(dSm^{-1}) + 25(mmol L^{-1})$^{1/2}$, T_4= 8 (dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$, T_5= 12 (dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_6= 12(dSm^{-1}) + 25 (mmol L^{-1})$^{1/2}$, T_7= 12(dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$, T_8= 16(dSm^{-1}) + 20(mmol L^{-1})$^{1/2}$, T_9= 16 (dSm^{-1}) + 25(mmol L^{-1})$^{1/2}$ and T_{10}= 16 (dSm^{-1}) + 30(mmol L^{-1})$^{1/2}$

Table 1: Influence of salinity plus sodicity on Plant height (cm) and stem diameter (cm) of Chiku (Achras zapota L.) seedlings

Conclusion

Increasing levels of salinity and sodicity had adverse influences on plant growth. Salinity cum sodicity minimum percentage increase over control was determined in T_{10} having EC (16 dSm^{-1}) and SAR 30 (mmol L^{-1})$^{1/2}$.

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