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GROWTH AND DEVELOPMENT OF GUAVA (*PSIDIUM GUAJAVA* L.) SEEDLINGS AGAINST SODIUM CHLORIDE SALINIZED WATER

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ABSTRACT

The categorization of genotypes having varying potential to salt-tolerance is an efficient approach to cope with the problems of saline soils and saline irrigation. A glasshouse experiment was carried out to evaluate the growth, development, and ions content in guava seedlings against sodium chloride salinized water. Sixty-day-old two commercial guava genotypes (Ramzani and Thadharamy) were irrigated with water of four salinity levels (control (distilled water), 1.5, 3.0 and 5.0 dS m^{-1}). The results indicate that increasing salinity levels negatively affected agronomic traits of both guava genotypes. A significant decline in height, stem girth, number of leaves $plant^{-1}$, dry weight of shoot and roots was noted at salinity level of 3.0 and 5.0 dS m^{-1}. Similarly, the seedlings grown under treatments of EC 1.5, 3.0 and 5.0 dS m^{-1} had higher Na^+ and Cl^- contents and less K^+ and Ca^{2+} content in comparison to control treatment. The significant variation was recorded among the guava genotypes. Ramzani produced taller plants, thicker stem, more leaves $plant^{-1}$, greater shoot and root dry weights, and less Na^+ and Cl^- contents in comparison to Thadharamy. We conclude that guava seedlings should not be irrigated with saline water having EC greater than 1.5 dS m^{-1}. Cultivation of Ramzani is a better choice in saline environment than Thadharamy.

Keywords: agronomic parameters, genotypes, guava, ions content, saline water

INTRODUCTION

Guava (*Psidium guajava* L.) is a perennial fruit tree of tropics and subtropics offering great economic potential (Kosky *et al*., 2005). It is highly known for its great aroma and protein content (Gonzaga *et al.,* 1999). It contains significant quantity of calcium, vitamin A, phosphorous, sulphur, potassium, chlorine, sodium, magnesium, iron, riboflavin, pantothenic acid, niacin and thiamin (FAO, 2009). It is originated in tropical America and now it is primarily produced in China, India, Pakistan, Thailand, Indonesia, Mexico, Bangladesh and Brazil (Ishtiaq *et al.,* 2012).

In arid and semi-arid regions, guava plants are irrigated with saline water and its growth is badly affected due to salinity (Cavalcante *et al.,* 2005). The causes behind decline in guava growth under salt stressed conditions are osmotic stress, nutritional inequality, specific ion toxicity and combination of overhead factors (Al-Yasin, 2004). The salinity has adverse interaction with high temperature of semi-arid regions which affect the salt uptake owing to increase in transpiration (Mittler, 2006). The adverse effect of salinity is more noticed at the seedling stages of many fruit plants e.g. mango, guava and passion fruit (Cavalcante *et al.,* 2001; Ebert, 2002; Raya *et al.,* 2004). Saline water present in soil and its constant application with varying salinity levels badly affects the plants and deteriorate soil physico-chemical properties. Under these conditions checking the quality of water for irrigation has great significance in relation to seedling production (Ayers and Westcot, 1999).

Guava is a salt-sensitive plant. Excess buildup of salts in mature leaves of sensitive species show negative effects, such as, quicker leaf chlorosis, necrosis and reduced photosynthetic activity (Neumann, 1997). The adverse effects of salts also vary with the type of salt present in soil and/or irrigation water. For

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example, as compared to calcium chloride ($CaCl_2$), sodium chloride (NaCl) is more deleterious for guava which inhibits germination, root and hypocotyl growth (Kaul *et al.,* 1988). This study was designed to study the effects of sodium chloride salinized water on growth and ions content of two guava genotypes. The outcome of this study will be helpful to find out the acceptable level of saline water for guava seedlings and choose the best guava genotype for saline environment.

MATERIALS AND METHODS

This pot study was laid out at Quaid-e-Awam Agriculture Research Institute during 2017 at Larkana, Sindh, Pakistan (located between 27.59 N and 68.26 E). The soil for the experiment was air-dried and passed through a garden sieve (¼ inches), then the soil was filled into large clay pots. The physico-chemical properties of the soil (10 kg) was analyzed before planting of guava seedlings. The soil was clay loam with alkaline pH (7.7), non-saline (EC 0.43 dS m^{-1}), low in organic matter (0.71%), marginal in exchangeable potassium (109 ppm K), with 0.71 meq L^{-1} sodium, and 13.06 meq L^{-1} calcium. The experiment was conducted under CRD factorial design with three replicates and two factors. Factor A was guava genotypes (G1= Ramzani and G2= Thadharamy) and Factor B was four salinity levels (S_1= distilled water (control), S_2= 1.5 dS m^{-1}, S_3= 3.0 dS m^{-1} and S_4= 5.0 dS m^{-1}). The saline water of desired concentrations (1.5, 3.0 and 5.0 dS m^{-1}) was prepared by dissolving the calculated quantity of NaCl salt (analytical grade) in the distilled water. About 60 days old healthy guava seedlings were obtained from a commercial nursery located at Larkana city. The initial data of plants regarding plant height, stem girth and number of leaves was recorded, before transferring them into pots. Plant height, stem girth, number of leaves plant^{-1} were counted after 120 days of seedling planting. Dry weight of shoot and root were noted at the end of experiment (4 months after planting). Topmost fully mature leaves were sampled and ground using Blender and Grinder Mill (Anex Germany Products). The plant samples were digested with HNO_3 and $HClO_4$ (2:1) using block digester. The concentration of Ca^{2+} and Cl^- in plant leaves was determined by titration method, while Na^+ and K^+ in leaf samples were determined using Flame photometer as described by Estefan *et al*. (2013). Data was statistically analyzed for Analysis of Variance (ANOVA) using statistical software Statistix 8.1.

RESULTS AND DISCUSSION

The results of the experiment had shown significant effect of salinity on the guava growth parameters, i.e. height, stem girth, number of leaves plant^{-1}, and shoot and root dry weight (Table 1). The increasing salinity levels significantly reduced height of guava seedlings. Maximum decline plant height was noted at 5.0 dS m^{-1} EC. The salinity levels EC: 1.5, 3.0 and 5.0 dS m^{-1} decreased plant height by 15.2, 36.2 and 54.6%, respectively over control treatment. The genotype Ramzani produced significantly taller plants as compared to genotype Thadharamy. In case of stem girth, significantly thinner stem girth was noted at salinity level of 3.0 and 5.0 dS m^{-1}. It can be seen from the data that the guava seedlings grown with EC 1.5, 3.0 and 5.0 dS m^{-1} produced 13.8, 51.5 and 62.8% thinner stem girth over control, respectively. Among the guava genotypes, Ramzani produced thicker stems than Thadharamy. In terms of number of leaves plant^{-1}, increasing salinity significantly reduced the number of leaves per plant. Significantly lesser number of leaves plant^{-1} was recorded at salinity level of 5.0 dS m^{-1}. The guava seedlings irrigated with EC 1.5, 3.0 and 5.0 dS m^{-1} had 17.2, 42.4 and 62.2% fewer leaves over control. Between the genotypes, Thadharamy produced more leaves plant^{-1} than Ramzani. The data related to shoot dry weight (g) of guava genotypes showed that the increasing salinity significantly reduced shoot dry weight of guava seedlings of both genotypes. The highest decrease in dry weight of shoots was noted at salinity level of 5.0 dS m^{-1}. Guava seedlings grown with EC 1.5, 3.0 and 5.0 dS m^{-1} water had 16.4, 36.0 and 64.5% lower shoot dry weight over control, respectively. Among the guava genotypes tested, Ramzani produced more shoot dry weight over Thadharamy. There was a constant decline in root dry weight with increasing salinity levels; significantly highest decline in dry weight of roots was noted at salinity 3.0 and 5.0 dS m^{-1}. Guava seedlings grown with the EC 1.5, 3.0 and 5.0 dS m^{-1} salinized water produced 15.4, 52.5 and 62.6% lower root dry weight over control, respectively.

Sodium and chloride contents in leaves were increased while potassium and calcium contents (%) in leaves of both guava genotypes significantly decreased as a function of saline waters (Table 2). The data on Na^+ content (%) in leaves showed that the highest Na^+ accumulation was noted at 5.0 dS m^{-1}. Guava seedlings irrigated with water of EC levels 1.5, 3.0 and 5.0 dS m^{-1} accumulated 2.5, 3.8, and 5.1 times more Na^+ in their leaves, respectively over control treatment. Between the guava genotypes, Thadharamy was found to accumulate more Na^+ than Ramzani. Increasing salinity considerably increased the Cl^- concentration in leaves of guava seedlings. Statistically the higher Cl^- accumulation was noted at 3.0 and 5.0 dS m^{-1} than all other treatments. The guava seedlings grown with sodium chloride salinized waters of 1.5, 3.0 and 5.0 dS m^{-1} accumulated 2.0, 3.7, and 4.7 times, respectively more Cl^- in their leaves over control treatment. Among the guava genotypes, Thadharamy had significantly more Cl^- content (%) over Ramzani. Increasing salinity considerably decreased leaf K^+ content; the highest K^+ accumulation was noted in control plants. The guava seedlings grown with EC 1.5, 3.0 and 5.0 dS m^{-1} accumulated 39.8, 68.2 and 85.2% lower K^+, respectively in their leaves, over control. Ramzani showed significantly more K^+ in its leaves as compared to Thadharamy. The results regarding Ca^{2+} content (%) in leaves of guava genotypes showed that leaf calcium reduced with enhancing salinity. The highest Ca^{2+} content was recorded in plants from control pots while significantly least Ca^{2+} was observed in saline water having EC 5.0 dS m^{-1}. There was 33.3, 52.4, and 71.4% less Ca^{2+} in leaves when the guava seedlings were irrigated with saline waters of 1.5, 3.0 and 5.0 dS m^{-1}, respectively. Ramzani accumulated significantly more Ca^{2+} in its leaves than Thadharamy.

In current study, the growth and development parameters of guava genotypes significantly reduced with increasing salinity. The higher values of all growth parameters were obtained from control treatments. However, at the higher concentrations of NaCl (3.0 and 5.0 dS m^{-1}) decline was noted in studied parameters. This indicates that salinity had hostile influence on guava genotypes. Adverse effects on growth with increasing salinity levels are reported by many researchers. Lourival *et al.* (2010) reported that the highly saline irrigation water significantly reduced plant length, leaf area, stem girth, length of roots, roots and shoot dry matter of guava seedlings. Tavares (2007) stated that the guava plants grown in saline water had less number of leaves with more dropping of leaves. Cavalcante *et al.* (2007) reported that salinity negatively influenced growth characters of four guava cultivars over control treatments by showing reduced stem diameter, plant height, number of leaves, leaf size and dry weight of shoot and roots. Salinity considerably reduces the growth of plant depending upon many factors including plant species, growth stage and salinity level (Aslam, 1995; Guan, *et al*., 2010). Many other researchers found that salinity has adverse effect on initial germination stage and further growth (Azza *et al.,* 2007; Feizi *et al*., 2007). Fanor *et al*. (2006) stated that under saline environment crops will experience reduction in seed germination and seedling growth possibly because of osmotic stress.

The Na^+ and Cl^- concentrations in guava leaves were greatly increased, while the K^+ and Ca^{2+} concentration in guava leaves was reduced with increasing salinity levels. The reason of high concentration of Na^+ and Cl^- in guava leaves was the applications of NaCl enriched saline water on soil. The reason for decreased K^+ and Ca^{2+} concentrations in guava leaves was the presence of Na^+ ions which are active competitors of K^+ and Ca^{2+} in plant uptake mechanism. Makhija *et al.* (1980) also reported that K^+, Ca^{2+} and Mg^{2+} in guava leaves was decreased with increasing salinity levels while Na^+ and Cl^- concentration was greatly increased. Maiti *et al*. (2006) found that increasing salinity levels > 1.4 dS m^{-1} significantly increased leaf Na^+ concentration but condensed K^+ and Ca^{2+} concentrations in selected field crops. Zekri (1998) observed that increasing salinity considerably increased Na^+, Cl^-, N and P concentration in guava shoots. However, it reduced K^+, Ca^{2+} and Mg^{2+} in the shoot of most rootstocks.

There was significant difference between guava genotypes, when grown under non-saline and saline conditions for all growth traits, including ion contents (Na^+, Cl^-, K^+, and Ca^{2+}) accumulation in leaves. Ramzani had significantly taller plants, thicker stem, more number of leaves, and shoots and roots dry weight, which may be associated to lower accumulation of Na^+ and Cl^- content and higher K^+ and Ca^{2+} content than Thadharamy. This suggests that the number of genes responsible for stress tolerance were possibly lacking in one genotype (Thadharamy) than the other (Ramzani). There are several evidences which point out that salinity induces change in genes expression in plants (Hurkman, 1992).

Table 1. Effect of sodium chloride salinized water on plant height (cm), stem girth, number of leaves, shoot and root dry weight of selected guava genotypes

Salt Treatments	Plant height (cm)	Stem girth (mm)	No. of leaves ($plant^{-1}$)	Shoot dry weight (g)	Root dry weight (g)
Control	33.91±0.40 [a]	7.01±0.46 [a]	36.47±0.22 [a]	7.78±0.02 [a]	7.87±0.07 [a]
1.5 dS m^{-1}	28.74±0.28 [b]	6.04±0.25 [b]	30.19±0.57 [b]	6.50±0.03 [b]	6.66±0.06 [b]
3.0 dS m^{-1}	21.64±0.19 [c]	3.40±0.63 [c]	20.99±0.63 [c]	4.98±0.01 [c]	3.74±0.03 [c]
5.0 dSm^{-1}	15.40±0.11 [d]	2.61±0.32 [c]	13.78±0.49 [d]	2.76±0.1 [d]	2.94±0.03 [c]
LSD (0.05)	1.6933	0.8370	2.0991	1.0027	0.8781
Genotypes					
Ramzani	26.54±0.27 [a]	6.31±0.24 [a]	27.73±0.39 [a]	6.38±0.05 [a]	5.88±0.06 [a]
Thadharamy	23.30±0.18 [b]	4.22±0.29 [b]	30.99±0.46 [b]	4.63±0.02 [b]	4.62±0.08 [b]
LSD (0.05)	1.1974	0.5919	1.4843	0.7090	0.6209

For salt treatments, each value is mean ± SD (*n* = 6); for genotypes, each value is mean ± SD (*n* = 12)

Table 2. Effect of sodium chloride salinized water on Na^+, Cl^- , K^+, and Ca^{2+} content in leaves of guava genotypes

Salt Treatments	Na^+ (%)	Cl^- (%)	K^+ (%)	Ca^{2+} (%)
Control	0.10±0.05 [d]	0.06±0.02 [c]	0.88±0.14 [a]	0.42±0.04 [a]
1.5 dS m^{-1}	0.25±0.07 [c]	0.12±0.01 [b]	0.53±0.12 [b]	0.28±0.03 [b]
3.0 dS m^{-1}	0.38±0.01 [b]	0.22±0.07 [a]	0.28±0.07 [c]	0.20±0.02 [c]
5.0 dS m^{-1}	0.51±0.01 [a]	0.28±0.02 [a]	0.13±0.05 [d]	0.12±0.01 [d]
LSD (0.05)	0.0106	0.0131	0.0167	0.0157
Genotypes				
Ramzani	0.24±0.05 [b]	0.17±0.02 [b]	0.45±0.06 [a]	0.26±0.03 [a]
Thadharamy	0.39±0.02 [a]	0.29±0.06 [a]	0.32±0.03 [b]	0.16±0.05 [b]
LSD (0.05)	0.0752	0.0238	0.0275	0.0111

For salt treatments, each value is mean ± SD (*n* = 6); for genotypes, each value is mean ± SD (*n* = 12)

CONCLUSION

The growth and development parameters (plant height, stem girth, number of leaves, shoot and root dry weight), and K^+ and Ca^{2+} contents were decreased while the Na^+ and Cl^- contents in leaves of guava genotypes were increased with the increased salinity levels (1.5 , 3.0 and 5.0 dS m^{-1}). A significant decline in these parameters was recorded with salinity level of 3.0 and 5.0 dS m^{-1} whereby 36 to 64% decrease in selected growth parameters was noticed. With these saline water levels, there was 52 to 85% decrease in K^+ and Ca^{2+} contents and 3.7 to 5.1 times increase in Na^+ and Cl^- contents. Ramzani showed better performance under saline conditions as compared to Thadharamy. We suggest that, for better growth and development, the guava seedlings should not be irrigated with saline water having EC > 1.5 dS m^{-1}.

AUTHOR'S CONTRIBUTION

J. A. Abbasi: Conducted research.
A. W. Gandahi: Supervisor.
M. Saleem: Co-supervisor.
S. M. Bhatti: Data analysis.
Z. R. Bughio: Interpretation of data.

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