90. Application of Saline Water Reduces Growth and Development of Jatropha (*Jatropha Curcas*, L.) Seedlings

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Abstract

Jatropha *(Jatropha curcas* L.) is a perennial biofuel shrub belong to family Euphorbiaceae and is known to have origin of Central America and Mexico. Nowadays, it is grown as a potential source of biodiesel energy instead of petroleum. Bio-fuels are considered as a part solution for sustainable development, energy security and decreasing of greenhouse gas effect on the ecology. The practice of irrigating jatropha seedlings with saline water continuously for two months in a pot experiment, adversely affected soil properties and jatropha seedlings. Compared to freshwater (0.46 dS m^{-1}), the jatropha seedlings irrigated with 2, 4, 6, 8, 10 and 12 EC_i (dS m^{-1}) showed 18, 31, 37, 45, 55 and 63 % reduction in height; 11, 21, 33, 44, 60 and 76 % fewer number of leaves ($plant^{-1}$); 5, 12, 19, 30, 39 and 42 % shorter leaves (cm) and gave 24, 36, 40, 45, 53 and 62 % lower shoot dry weight ($plant^{-1}$) respectively. The adverse effects of brackish water on growth and development of jatropha seedlings were associated with the more Na^+, less K^+ and lower leaf K^+/Na^+ ratio.

Keywords: *Jatropha, saline water, growth and development.*

1. Introduction

The impact of saline water use on crops and soil becomes increasingly important to the growers of Sindh. Before irrigating their crops with saline water, the farmers should try to evaluate quality and availability of that water and its possible impact on plants and soil properties. Saline water decreases growth and water contents of plants and also decreases oil yield of plants (Maes *et al*., 2009; Silva *et al*., 2010). The bio-fuel plants available in Sindh consist of jatropha, castor oil, flax, etc. Among these, the jatropha has recently been introduced and adopted by some growers in the Sindh province; just to minimize the fuel and energy crises and demand of the country. The response of jatropha plant to salts may give an important clue for its adaptation to saline irrigation stress. In Pakistan particularly in Sindh province groundwater quality does not meet the standards drafted by the country for the crop use. Although, salinity has become an alarming problem of agriculture throughout the world, the development of this menace is of a greater magnitude in arid and semi-arid areas. This is mainly due to high transpiration and low precipitation, which disturb the salt balance in the soil; this also enhance brackishness of groundwater and ultimately induce negative impact on plant growth (Rhoades and Lovaday, 1990; Evans, 1998). Jatropha (*Jtropha curcas* L.) is belong to Euphorbiaceae, oil yielding family and is known to have an origin of Central America and Mexico. The genus jatropha has 476 species and is distributed throughout the world; it is a hardy and drought tolerant plant as well; it can be cultivate on poor lands with inadequate inputs (Srivastava, 1999; Patil and Bhandare, 2003). Jatropha is now promoted as a biodiesel crop in comparison with petro diesel to mitigate the global warming pressure (Wilson, 2010). Recently, jatropha has received much attention as a potential source of energy (Biofuel) that can replace petroleum, and in particular the production of biodiesel (Andrew *et al.,* 2009). Biodiesel, an environment friendly fuel similar to petro-diesel in combustion properties, has received considerable attention in the recent past worldwide. Jatropha oil can safely be used for transportation by blending up-to 20% with petro-diesel. However, the refined oil is a qualified neat biodiesel. Jatropha grows well under subtropical and tropical climates. Bio-diesel is a methyl or ethyl ester of fatty acid made from renewable biological resources such as vegetable oils (both edible and non-edible), recycled waste of vegetable oil and animal fats (Demirbas, 2000; Kinney and Clemente, 2005; Wilson *et al*., 2005). The better growth and development for jatropha is observed on sandy and sandy loam soils of at least 45 cm depth (Gour, 2006). Heavy soils are less suitable for jatropha cultivation due to very poor drainage, jatropha is intolerant of waterlogged conditions while it is reported that jatropha has ability to grow in alkaline soils, having soil pH range should be within 6.0 to 8.0/8.5 (FACT, 2007). Jatropha oil is an environmentally safe and cost-effective renewable source of non-conventional energy and promising substitute for diesel, kerosene and other fuels. Almost three quarters of the surface of the earth is covered by salt water and so it is not surprising that salts affect a significant proportion of the world's land surface. Pakistan is arid to semi-arid country, located between the longitudes 61° east to 76° east and between latitude 23° north to 37° north. It is also reported that about 70% tube-wells are pumping saline sodic water for irrigation on in Indus basin. The soils irrigated with saline sodic water turns into sodic from saline soil and crops yield also severely affected (Khloon *et al.,* 2003). However, variation may occur for salinity tolerance in different plants. This paper reports the response of jatropha seedlings to saline water.

2. Materials and Methods

This experiment was conducted in a wire-house at the Center for Bio saline Agriculture, Department of Soil Science, Faculty of Crop Production, Sindh Agriculture University, Tandojam. The soil was collected from Latif Experimental farm of Sindh Agriculture University, Tandojam. The air-dried soil (l kg bag^{-1}) was placed in polyethylene bags with drainage holes at bottom. The polyethylene bags were placed on wooden benches of wire house in a completely randomized design order. Jatropha seed (provided by Pakistan Bio-fuels Karachi, Sindh), were placed 1 cm deep and 2 cm apart. After emergence, only one seedling was allowed to grow in each polyethylene bag. Groundwater having EC_i 12 dS m^{-1}, pH 7.95 and SAR 27 was collected from the field (near Detha Railway Station on Hyderabad-Mirpurkhas Road). Seven saline water treatments (T_1: control/ canal water EC_i 0.46 dS m^{-1}, T_2: EC_i 2 dS m^{-1}, T_3: EC_i 4 dS m^{-1}, T_4: EC_i 6 dS m^{-1}, T_5: EC_i 8 dS m^{-1}, T_6: EC_i 10 dS m^{-1} and T_7: EC_i 12 dS m^{-1}) were established by blending brackish groundwater with canal water (EC_i 0.46 dS m^{-1}). In saline water treatments, plants were receiving continuously salty water, whereas in control, plants were regularly irrigated with canal water only. Sixty days after sowing, the experiment was terminated and plants were removed carefully from each bag to record plant height (cm), leaf length and shoot dry weight ($plant^{-1}$). Fully expanded top leaves were detached, placed in paper bags after chopping into small pieces and then oven dried at 70 ºC for 48 hours. Further more samples were ground through a mill and then processed for analyses of Na^+ and K^+ by flame photometry USSL, 1954). Before experimentation the soil was analyzed for texture, EC_e, pH, organic matter (%), Na^+, K^+, Ca^{2+} and Mg^{2+} contents, following the appropriate methods of soil analysis adopted by the Department of Soil Science. Exchangeable sodium percentage was calculated by the formula of Rowell (1954). The plant data was processed and analyzed statistically using MINITAB .12. Software.

3. Results and Discussion

Practice of using saline water seemed to be adversely effective for both soil and jatropha plants. The soil data given in the Table-1 and 2, indicate that as related to control (0.46 dS m^{-1}), the soil received saline water turned into saline-sodic i.e. it showed rise in exchangeable sodium percentage (ESP) and EC_e (dS m^{-1}) as well. This clearly suggests that care must be taken while irrigating soils with saline water because saline water increases the salt concentration in soil. Several studies conducted on investigating the adverse effect of saline water on soils revealed that saline water used in agriculture increases salinity and sodicity problem in soil (Gupta, 1990).

Table 1. Soil properties before planting and at harvest

Property	Before planting	At harvest
Texture	Sand 69 % Silt 17.5% Clay 13.5%	-
Textural Class	Sandy loam	-
EC_e (dS m^{-1})	0.26	7.80
pH (H_2O)	7.10	7.90
Organic matter (%)	0.45	-
ESP (%)	0.14	18.60
$CaCO_3$ (%)	8.70	8.79

Table 2. Effect of saline irrigation water on change in Soil ECe (dS m^{-1}) and pH respectively.

EC_i (dS m^{-1}) of irrigation water	At harvest, EC_e (dS m^{-1}) of soil	At harvest, pH of soil
0.46	0.26	7.10
2	1.30	7.25
4	2.47	7.39
6	3.90	7.43
8	5.83	7.67
10	6.27	7.77
12	7.81	7.90

Table 3. Effect of saline irrigation water on number of leaves (plant^{-1}), Leaf length (cm) and shot dry weight (g) (plant^{-1}).

EC_e (dS m^{-1})	Number of leaves (plant^{-1})	ROC (%)	Leaf length (cm)	ROC (%)	Shoot dry weight (g) (plant^{-1})	ROC (%)
Control (0.46)	36.00±0.001	-	36.00±0.001	-	32.00±0.001	-
2	32.0±0.210	11.0	34.0±0.050	5.0	24.29±0.064	24.0
4	28.4±0.401	21.0	31.6±0.060	12.0	20.60±0.061	36.0
6	24.0±0.307	33.0	29.1±0.030	19.0	19.00±0.042	40.0
8	20.0±0.307	44.0	25.0±0.365	30.0	17.80±0.020	45.0
10	14.4±0.210	60.0	21.9±0.307	39.0	15.00±0.210	53.0
12	08.4±0.026	76.0	20.8±0.258	42.0	12.15±0.021	62.0

*ROC: Reduction over control,

Table 4. Effect of saline water on leaves Na^+, K^+, Cl^- and K^+/Na^+ ratio determined in the jatropha leaf tissue.

EC_e (dS m^{-1})	Leaf Na^+ (%)	*IOC (%)	Leaf Cl^- (%)	*IOC (%)	Leaf K^+ (%)	*ROC (%)	K^+/Na^+ (%)	*ROC (%)
0.46	0.43	-	0.05	-	1.35	-	3.23	-
2	0.957±0. 000	109	0.113±0.000	053	1.201±0.000	11	1.350±0.003	58
4	1.201±0. 002	137	0.222±0.001	105	1.039±0.001	23	1.030±0.000	68
6	1.590±0. 003	181	0.331±0.002	156	0.796±0.001	41	0.466±0.002	80
8	1.990±0. 004	228	0.443±0.001	209	0.634±0.000	53	0.451±0.000	86
10	2.340±0. 003	267	0.534±0.003	252	0.580±0.001	57	0.323±0.000	90
12	2.800±0. 005	319	0.534±0.004	315	0.540±0.003	60	0.032±0.000	100

*ROC: Reduction over control, *IOC: Reduction over control,

As shown in the Tables 3 and 4, the data related to agronomical observations indicate that water salinity had negative impact on the growth and development of jatropha seedlings, it decreased number and length of leaves. This suggests that the adverse effect of water salinity on plants was possibly due to the ion-specific effect of Na^+ and Cl^-, when these toxic ions accumulate in higher centration in the leaves, leaves become narrow/small in size and do not emerge at normal rate. It is also well documented that salinity reduces the rate at which growing leaves expand and the leaves emerge very slowly (Munns and Tester, 2008). It is also clear from this study that the seedlings grew in saline water environment were shorter in height (cm) and had very thin stem. The stress given by water salinity largely decreased shoot dry weight of jatropha seedlings. The reduction in shoot dry weight occurred possibly due to the rapid increase in external osmotic pressure and accumulation of Na^+ in leaves (Lauchli, 1984; Storey and Walker, 1999). That reduction in leaf growth under saline environment is also regulated by plant hormones (Tracy *et al.*, 2008; Knight *et al.*, 2002). In several previous reports (Harcle*et al.*, 2008) it is clearly written that salinity is negative to leaf production and other important growth parameters of various cops and plants. A study conducted by Sharma *et al.*, (2008) indicates that water salinity reduces shoot and leaf growth of plants, possibly creating change in osmotic or water potential and ionic toxicity caused by the Na^+ and Cl^- ions. Decrease in internal water content and water potential of plant cells has also been found negative to shoot growth, by various scientists including Munns and Tester (2008); Patel *et al.* (2010). The impact of saline irrigation on the growth of plants is considered as ionic effect; that starts much later than the osmotic effect. In this study compared to freshwater, the jatropha seedlings irrigated with saline water contained more Na^+ and Cl^- which are toxic in nature and less K^+, which is considered as quality enhancing, nutrient elements. That suggests the antagonistic effect of Na^+ for K^+ under saline irrigation environment. It is evident from various other reports that plants respond directly and specifically to the addition of Na^+ within seconds (Knight, 2002; Tracy *et al*., 2008). Leaf blade has been reported as the main site of plants to accumulate Na^+ (Munns, 2002). At this site more Na^+ accumulated, rather than in roots. Once the Na^+ is delivered to shoot, much amount of it remains in the shoot (Munns and Tester, 2008). Finally the study indicated that using saline water to irrigate jatropha plants is adverse, water EC_i beyond 2 dS m^{-1} showed more than 20% reduction in majority of the parameters. Hence, the jatropha seedlings may not be irrigated with saline water having ECi above 2 dS m^{-1}.

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