

Growth and Ionic Composition of Buttonwood (*Conocarpus erectus* L.) in Response to Soil Salinity and Water Stress

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Abstract

Salinity and bad quality irrigation water is very common problem in Pakistan due to limited rainfall, more evapo-transpiration and high temperature. So, there is need to select salt and drought tolerant plants. In view of that a pot experiment was conducted to study the growth performance and ionic composition of *Conocarpus erectus* L. under saline and water stress conditions. Eight treatments (Control, 10 dSm⁻¹, 20 dSm⁻¹, 40 dSm⁻¹, water stress, 10 dSm⁻¹ + water stress, 20 dSm⁻¹ + water stress, 40 dSm⁻¹ + water stress) were evaluated in order to assess their effect on plant growth and ionic composition. At T₈ (40 dSm⁻¹ + water stress), plants did not survive. The data regarding growth parameters and physiological were recorded at different stages of plant growth. Plant ionic parameters including Na⁺, K⁺ were determined in stem, leaves and root after harvesting. The data were analyzed statistically. It is concluded that *Conocarpus erectus* L. can tolerate salinity up to 40dSm⁻¹ with full water but at salinity and water stress level of 40 dSm⁻¹ + water stress, there was no survival of even a single plant.

Keywords: Growth, potassium status, buttonwood (*Conocarpus erectus* L.), soil salinity, water stress

1. INTRODUCTION

There are many abiotic stresses for a plant but salinity is a major abiotic stress (Rahman *et al.*, 2004). According to a survey 7% of the world's land area is affected by salinity which contributes to 930 million ha (Szabolcs, 1994). On the average 13% area in Punjab and 25% area in Pakistan is affected by salinity. On the acreage basis it is about 3 million acres in Punjab and 10 million acres in Pakistan (Ahmad and Chaudhry, 1997). It has been estimated that about 954 million hectares around the world and 6.67 million hectares in Pakistan are affected by salinity (Khan, 1998).

Saline soils have adverse effects on plant growth and cause plant death due to ion toxicity, water stress, ion imbalance, or a combination of all these factors (Bor *et al.*, 2003). To understand how plants face extra Na⁺ in the environment is of great agricultural importance because soil salinity brings out large yield losses in crops in the whole world. Na⁺ stress interferes K⁺ entry by root cells. When Na⁺ moves into the cells and gathered to high levels, it becomes harmful to enzymes (Hasegawa *et al.*, 2000). Many studies in mangroves have connection with the effects of salinity on respiration and photosynthesis (Fukushima *et al.*, 1997).

Plants have developed different mechanisms to deal with salinity effects (Munns, 2002). To prevent growth break off, excessive Na has to be expelled or divided up into compartments in the vacuole (Hasegawa *et al.*, 2000). In some species, salt concentration can also be reduced by transferring the salts into old leaves or by storing them in the bark or the wood. Salinity and drought are most familiar abiotic stresses that effect plant growth and limit the many physiological processes such as photosynthetic rate, mineral distribution and membrane permeability (Qin *et al.*, 2010). Salinity decreased the photosynthetic rate of most of the plant species. Plants grown under saline soils were subjected to water stress and uptake of water by plants was decreased which ultimately decreased the transpiration rate (Munns, 2002). Under saline and water stress plant closed its stomata which protect the plant from dehydration. However closing of stomata also stop the exchange of carbon dioxide and oxygen between outside atmospheric air and its internal tissue. This condition decreased the uptake of nutrients by plant and slows down metabolism in plant and decreased the chances of plant survival (Tang *et al.*, 2002).

Buttonwood is a seaside shrub or tree with highly salt-resistant foliage. *Conocarpus sp.* is known as one of salt tolerant forest species and their native habitats are moist. Buttonwood (*Conocarpus erectus* L.), is an evergreen shrub of family *Combretaceae* native to Florida's mangrove forest ecosystem in North America. It is found on the edges of salt flats, rock lands of the Florida Keys, edges of hammocks, borders of fresh and brackish marshes in South Florida. Buttonwood can tolerate severe desert heat where summer temperatures may reach 47°C and these can also grow in soils of very low fertility (Nelson, 1996). *Conocarpus erectus* is a source of food for wildlife and it also protects the soil during storm and helps to fix dunes. Buttonwood (*Conocarpus erectus* L.) is planted as ornamental plant in yards, streets, parking lots and parks. The wood of *Conocarpus erectus* is durable and is used to make posts for turnery, railroad ties, fuel, buildings, boats, and charcoal. Its bark and leaves are being used in tannery. Buttonwood is reported to be a soft, non-toxic and attractive plant to feed

animals because its green residues branches and shoots are used as fodder (Suleiman *et al.*, 2005). Button mangrove is a folk remedy for catarrh, anemia, diarrhea, conjunctivitis, diabetes, fever, headache, gonorrhoea, hemorrhage, orchitis, swellings, prickly heat, and syphilis (Morton, 1981).

The use of economically useful salt tolerant plants in rehabilitation programmed for a saline ecosystem would be a useful option (Khan and Gul, 2006). **Considering the importance of buttonwood (*Conocarpus erectus* L.) a pot experiment was carried out to evaluate the effect of various salinity and water stress levels on the growth performance and ionic composition of buttonwood (*Conocarpus erectus* L.). **These results can be helpful for the cultivation of barren lands.****

2. MATERIALS AND METHODS

2.1. Study area and Experimental details

To study the effect of salinity and drought on *Conocarpus erectus* L. a pot experiment was conducted in the wire house of Saline Agriculture Research Centre, Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. For this purpose following materials and methods were used. Before salinity development soil samples were collected from normal soil and analyzed. Samples were analyzed for pH, ECe, SAR, soluble cations (Na^+ , K^+ , Ca^{+2} + Mg^{+2}), soluble anions (CO_3^{-2} , HCO_3^- , Cl^-), saturation percentage and textural class according to the standard methods described in USDA Handbook No. 60 (Richards, 1954).

Table 1. Physico-chemical properties of soil.

Characteristic	Unit	Values
Texture		Loam
Sand	%	36.48 ± 0.46
Silt	%	42.72± 0.91
Clay	%	20.8 ± 0.83
Saturation percenage	%	28±1.71
CEC	cmolc kg-1	8.31±0.27
OM	%	0.79 ±0.14
pH		7.52±0.03
SAR	(mmolcL-1)1/2	8.55±0.46
ECe	dS m-1	2.57±0.32
$\text{Ca}^{2+}+\text{Mg}^{2+}$	meL ⁻¹	23.18±1.51
Na^+	meL ⁻¹	29.12±0.27
K^+	meL ⁻¹	1.71±0.31

Nursery was established in wire house. Polyethylene bags were filled with sand and soil mixture and then 3 to 5 healthy seeds were sown in each bag. 25 bags were filled. Nursery was established in three months. Plants were watered as and when needed. Soil was first air dried and then sieved. Plastic pots were used for the experiment and each pot was filled with 10 kg of soil. Eight levels of salinity and drought (Control, 10 dSm⁻¹, 20 dSm⁻¹, 40 dSm⁻¹, water stress, 10 dSm⁻¹ + water stress, 20 dSm⁻¹ + water stress, 40 dSm⁻¹ + water stress) were developed by adding calculated amounts of NaCl. For developing salinity we use NaCl because it is easily available and cheaper salt. There were four replications of each salinity level and were arranged according to completely randomize design in factorial arrangement. Water was applied at 75% water content (well-watered) and 30% water content (water stressed) of field capacity. After salinity development soil was sampled from each salinity level and again analyzed for EC to confirm the developed salinity. Three month old healthy and uniform seedlings of *Conocarpus erectus* were transplanted to the pots.

2.2. Data collection and chemical analysis

Data regarding physical growth parameters of plants were collected after every three months. Plant height was measured from base to the top of the stem in cm with meter rod after every three months. Stem diameter was measured with venire calipers from 5 cm above the soil surface after every three months. Leaves and branches were counted after every three months. Analysis of sodium and potassium of root and stem and leaves was done after harvesting the plants. Different physiological parameters (photosynthetic rate, transpiration rate, stomatal conductance) of fully expanded second leaf of each *conocarpus* plant was determined using an open system LCA-4 ADC portable infrared gas analyzer (Analytical Development Company, Hoddesdon, England). These measurements were made from 10:30 a.m to 2:30 p.m with the following specifications/adjustments: temperature of leaf chamber varied from 34.5 to 39.6 °C, ambient pressure 991 mBar, ambient CO₂ concentration (C_{ref}) 373 μmol mol⁻¹, sub-stomatal CO₂ concentration (C_i) 115-312 μmol mol⁻¹, average water vapor pressure into chamber 34.6 mBar, molar flow of air per unit leaf area (U_s) 206.6 mol m⁻²s⁻¹, PAR (Q leaf) at the leaf surface was maximum up to 1200 μmol m⁻²s⁻¹.

2.3. Statistical analysis

Statistical analysis of the data thus collected for various parameters of plants was carried out by

computing ANOVA in CRD factorial using the software “Statistics”. Standard error of mean was calculated for comparison of treatment means (Steel *et al.*, 1997).

3. RESULTS

3.1. Salinity and water stress effect on plant growth parameters

3.1.1. Plant Height (cm)

The effect of salinity and water stress on plant height was significant (Figure 1a). The data regarding plant height was taken after every 3 months. With increased in salinity plant height was decreased. During first 3 month, at control, plant height of *Conocarpus erectus* was recorded 74.5 cm. The maximum decreased in plant height was recorded at salinity level of 40 dS/m 28.25cm and it was 62% less as compared to control, followed by 60% and 50% reduction at salinity levels of 20 dS/m+ water stress, and 10 dS/m + water stress respectively. After 6 months, in control plant height was 120.75 cm, there was maximum decreased in plant height was 64% at salinity level of 20 dS/m+ water stress as compared to control, followed by salinity levels of 40 dS/m and 10 dS/m + water stress that was 62% and 43% respectively. After 9 months, in control the plant height was 149 cm. Maximum decreased in height was 65% at salinity level of 20 dS/m + water stress as compared to control, followed by salinity levels of 40 dS/m and 10 dS/m + water stress where reduction was 61% and 40% respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.1.2. Stem Diameter (cm)

The effect of salinity and water stress on stem diameter was significant (Figure 1b). The data regarding stem diameter was taken after every 3 months. Stem diameter was affected by salinity and, with increased in salinity stem diameter was decreased. During first 3 month, in control the mean stem diameter was 0.52 cm. The maximum decreased in stem diameter was observed at salinity level of 40 dS/m that was 74% less as compared to control, followed by salinity levels of 20 dS/m + water stress and 10 dS/m + water stress, 73% and 50% reduction respectively. After 6 month, in control the mean stem diameter of plants was 0.75 cm. The maximum decreased 66% was observed at salinity level of 40 dS/m as compared to control, followed by 61% and 44% reduction at salinity levels 20 dS/m + water stress and 10 dS/m+ water stress respectively. After 9 month, in control the mean stem diameter was 0.99 cm was observed and maximum decreased 64% was recorded at 40 dS/m followed by salinity levels 20 dS/m + water stress and 10 dS/m + water stress and showed a decreased 62% and 47% respectively as compared to control. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

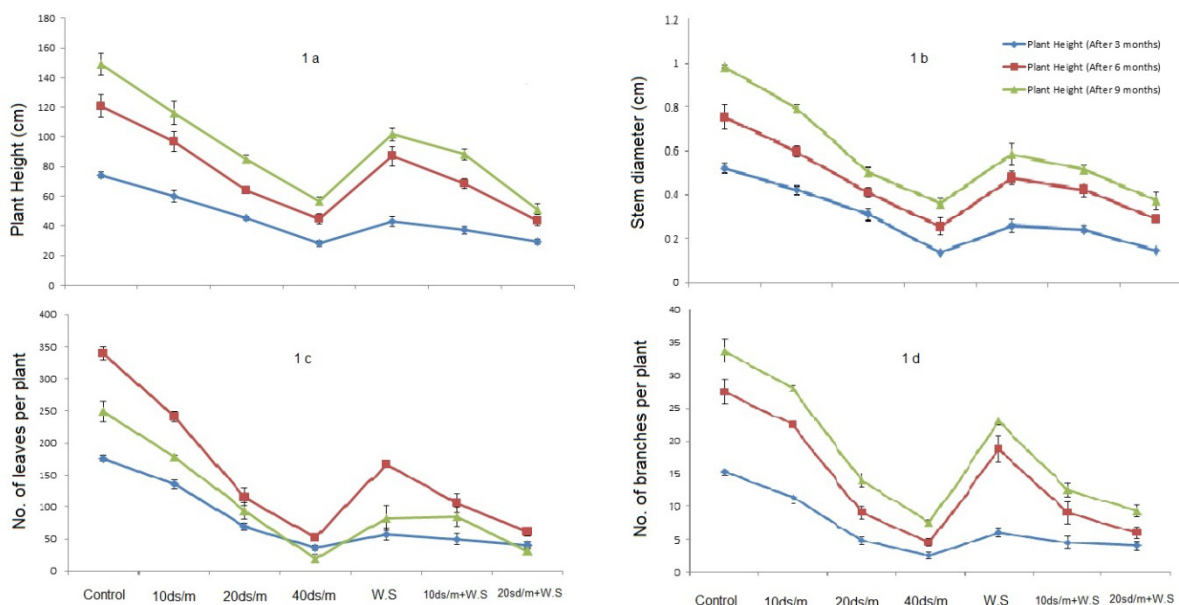


Figure. 1 Effect of salinity and water stress on plant height (cm), stem diameter (cm), No. of leaves per plant and No. of branches per plant.

3.1.3. No. of leaves per plant

Figure 1c shows that there is the significant effect of salinity and water stress on number of leaves. The data regarding number of leaves per plant of *Conocarpus erectus* was taken after every 3 months. Salinity have negative effect on number of leaves resultantly no. of leaves per plant decreased by increased the saline stress. During first 3 month in control, no. of leaves per plant of *Conocarpus erectus* was 177. The highest decreased in

no. of leaves per plant was 80% at salinity level of 40 dS/m , followed by salinity levels of 20 dS/m + water stress and 10 dS/m+ water stress, the decreased was 77% and 71% respectively as compared to control. After 6 months, in control the mean of no. of leaves per plant 339. The maximum decreased was 84% observed at salinity level of 40 dS/m as compared to control, followed by salinity levels of 20 dS/m + water stress and 10 dS/m+ water stress that was 82% and 68% reduction respectively as compared to control. After 9 month, in control the mean value of no. of leaves per plant was 250. The maximum decreased in no. of leaves per plant was recorded at salinity level of 40 dS/m , that was 92% decreased as compared to control, followed by the salinity levels of 20 dS/m + water stress and 10 dS/m+ water stress, that was 87% and 66% decreased as compared to control. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.1.4. No. of branches per plant

The effect of salinity and water stress on number of leaves was significant (Figure 1d). The data regarding number of branches of *Conocarpus erectus* was taken after every 3 month in a year. Due to the negative effect of salinity on plant the no. of branches were decreased due to increased saline stress. During first 3 month, in control, the mean of no. of branches per plant of *Conocarpus erectus* was 15. The maximum decreased was 83 % observed at salinity levels of 40 dS/m, followed by salinity level of 20 dS/m+ water stress and 10 dS/m + water stress that was 73% and 70% decreased as compared to control. After 6 month in control, the mean of no. of branches per plant was 28. The Maximum decreased was 84% observed at salinity level of 40 dS/m as compared to control. The same trend of decreased was observed at salinity level 20 dS/m+ water stress and at 10 dS/m + water stress that was 78% and 67% as compared to control. After 9 month in control, the mean of no. of branches per plant was 34. The maximum decreased was 77% at salinity level of 40 dS/m, followed by salinity level of 20 dS/m+ water stress and 10 dS/m + water stress that was 72% and 62% decreased as compared to control. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.1.5. Root fresh and dry weight (g/plant)

The effect of salinity and water stress on root fresh weight was significant (Table. 2). Salinity and water stress have obligatory negative effect on root fresh weight. Root fresh weight of *Conocarpus erectus* was decreased by increased in salinity and water stress. In control, the mean value of root fresh weight of *Conocarpus erectus* was 70 gram per plant. The maximum decreased in root fresh weight 78% was observed at salinity level of 40 dS/m as compared to control, followed by the level of salinity at 20 dS/m+ water stress and at salinity level of 10 dS/m + water stress that was 70% and 47% reduction respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

Table 2. Effect of salinity and water stress on biomass weight

Treatments	Root		Shoot	
	Fresh weight	Dry weight	Fresh weight	Dry weight
Control	70±2.41	11.67±0.60	151.36±5.08	37.84±1.27
10dS/m	61.72±3.60	10.29±0.90	125.46±3.70	31.36±0.93
20dS/m	40.92±3.11	6.82±0.78	87.5±2.86	21.87±0.71
40dS/m	13.22±2.02	2.20±0.45	15.08±2.54	3.76±0.63
W.S	32.21±2.27	5.37±0.57	58.98±9.79	14.74±2.45
10dS/m+W.S	29.30±0.74	4.88±0.19	52.87±4.58	13.21±1.14
20dS/m+W.S	18.32±0.51	3.05±0.13	20.54±2.04	5.13±0.51

3.1.6. Shoot fresh and dry weight (g/plant)

The effect of salinity and water stress on shoot fresh weight was significant (Table. 2). Saline and water stress have obligatory negative effect on shoot fresh weight. Shoot fresh weight of *Conocarpus erectus* plant was decreased by increased in salinity and water stress. In control, the observed mean value of shoot fresh weight of *Conocarpus erectus* was 151.36 gram per plant. The maximum decreased in shoot fresh weight 90% was observed at salinity and water stress level of 40 dS/m as compared to control, followed by the level of salinity and water stress 20 dS/m + water stress and at salinity level of 10 dS/m+ water stress that was 86% and 65% reduction respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.2. Physiological parameters affected by salinity and water stress

3.2.1. Photosynthetic Rate ($\mu\text{mol m}^{-2} \text{sec}^{-1}$)

The table 3 represented the photosynthetic rate. The graph showed that data about photosynthetic rate were statistically significant among the treatments. Salinity and water stress have negative effect on photosynthetic rate. Photosynthetic rate of *Conocarpus erectus* was decreased by increased in salinity and water stress. At control level, photosynthetic rate was maximum and mean value of photosynthetic rate of was 6.43 $\mu\text{mol m}^{-2}\text{sec}^{-1}$. The maximum decreased in photosynthetic rate 73% was observed at salinity and water stress level of 40 dS/m as compared to control level, followed by the level of salinity and water stress 20 dS/m + water

stress and at salinity level of 10 dS/m that was 67% and 45% respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.2.2. Transpiration rate ($\text{mmol m}^{-2}\text{sec}^{-1}$)

The table 3 represented the transpiration rate. The graph showed that data about transpiration rate were statistically significant among the treatments. Salinity and water stress have negative effect on transpiration rate. Transpiration rate of *Conocarpus erectus* was decreased by increased in salinity and water stress. At control level, transpiration rate was maximum and mean value of transpiration rate of *Conocarpus erectus* was $1.97 \text{ mmol m}^{-2}\text{sec}^{-1}$. The maximum decreased in transpiration rate 70% was observed at salinity level of 40 dS/m as compared to control level followed by the level of salinity at 20 dS/m+ water stress and salinity and water stress level at 10 dS/m + water stress that was 52% and 38% respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.2.3. Stomatal conductance ($\text{mmol m}^{-2}\text{sec}^{-1}$)

The table 3 represented the stomatal conductance. The graph showed that data about stomatal conductance were statistically significant among the treatments. Salinity and water stress have negative effect on stomatal conductance. Stomatal conductance of *Conocarpus erectus* was decreased by increased in salinity and water stress. At control level, stomatal conductance was maximum and mean value of stomatal conductance of *Conocarpus erectus* was $0.063 \text{ mmol m}^{-2}\text{sec}^{-1}$. The maximum decreased in stomatal conductance 87% was observed at salinity level of 40 dS/m as compared to control level, followed by the level of salinity and water stress 20 dS/m + water stress and at salinity and water stress level of 10 dS/m+ water stress that was 81% and 65% respectively. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

Table 3. Effect of salinity and water stress on plant physiological parameters

Treatments	Photosynthetic Rate ($\mu\text{mol m}^{-2}\text{sec}^{-1}$)	Transpiration Rate ($\text{mmol m}^{-2}\text{sec}^{-1}$)	Stomatal Conductance ($\text{mmol m}^{-2}\text{sec}^{-1}$)
Control	6.43±0.07	1.97±0.05	0.063±0.02
10dS/m	5.35±0.04	1.56±0.05	0.041±0.01
20dS/m	4.16±0.05	1.32±0.04	0.023±0.01
40dS/m	2.25±0.03	1.11±0.04	0.015±0.01
W.S	5.44±0.05	1.78±0.04	0.052±0.02
10dS/m+W.S	3.43±0.08	1.42±0.04	0.035±0.01
20dS/m+W.S	2.13±0.02	1.21±0.02	0.018±0.005

3.3. Effect of salinity and water stress on plant Na^+ and K^+ status

3.3.1. Sodium contents in different plant parts ($\text{mmol g}^{-1}\text{dw}$)

Plants grown under saline condition were subjected to sodium ion and to inspect the performance of plants on these saline soils the sodium concentration was measured. The effect of salinity and water stress on root sodium was significant (Table. 4). Root shows high concentration of sodium under saline and water stress conditions than under non-saline conditions. Maximum Na^+ contents in root was recorded 3.12 mmol/g dw at salinity and water stress level of 40 dS/m followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 2.33 and 1.25 mmol/g dw respectively. In control Na^+ contents in root was 0.15 mmol/g dw . At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph. Maximum Na^+ contents in shoot was recorded 2.62 mmol/g dw at salinity and water stress level of 40 dS/m + water stress followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 2.05 and 1.11 mmol/g dw respectively. In control Na^+ contents in root was 0.13 mmol/g dw . At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph. Maximum Na^+ contents in leaf was recorded 2.33 mmol/g dw at salinity and water stress level of 40 dS/m followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 1.86 and 1.05 mmol/g dw respectively. At control Na^+ contents in leaf was 0.12 mmol/g dw was recorded. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

3.3.2. Potassium contents in different plant parts ($\text{mmol g}^{-1}\text{dw}$)

Potassium concentration is determined to access the salinity tolerance of plants. It is thought an important tool under saline condition. The increased in salinity decreased the K^+ concentration. The effect of salinity and water stress on root, shoot and leaves contents of potassium were significant (Table. 4). Root shows high concentration of sodium under saline and water stress conditions than under non-saline conditions. Maximum decreased in K^+ contents was recorded 0.23 mmol/g dw at salinity and water stress level of 40 dS/m followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 0.27 and 0.38 mmol/g dw respectively. At control K^+ contents in shoot was 0.55 mmol/g dw was recorded. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph. Maximum decreased in K^+ contents was recorded 0.31 mmol/g dw at salinity and water

stress level of 40 dS/m followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 0.37 and 0.45 mmol/g dw respectively.

Table 4. Effect of salinity and water stress on ion composition of *Conocarpus erectus* L.

TREATMENT	Sodium (mm/g)			Potassium (mm/g)		
	Root	Stem	Leaf	Root	Stem	Leaf
Control	0.15±0.017	0.13±0.020	0.12±0.021	0.55±0.026	0.63±0.042	1.59±0.050
10dS/m	0.78±0.017	0.65±0.027	0.57±0.030	0.43±0.037	0.51±0.026	0.94±0.045
20dS/m	1.87±0.027	1.5±0.041	1.27±0.026	0.35±0.029	0.42±0.039	0.83±0.017
40dS/m	3.12±0.031	2.62±0.47	2.33±0.033	0.23±0.018	0.31±0.023	0.68±0.032
W.S	0.19±0.018	0.17±0.023	0.15±0.015	0.49±0.032	0.56±0.030	1.23±0.025
10dS/m+W.S	1.25±0.29	1.11±0.022	1.05±0.077	0.38±0.020	0.45±0.032	0.86±0.017
20dS/m+W.S	2.33±0.33	2.05±0.077	1.85±0.027	0.27±0.009	0.37±0.025	0.74±0.019

At control K⁺ contents in root was 0.63 mmol/g dw was recorded. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph. In our experiment the maximum decreased in K⁺ contents in leaf was recorded 0.68 mmol/g dw at salinity and water stress level of 40 dS/m followed by the salinity level of 20 dS/m+ water stress and salinity and water stress level of 10 dS/m + water stress that was 0.74 and 0.86 mmol/g dw respectively. At control K⁺ contents in shoot was 1.59 mmol/g dw was recorded. At salinity and water stress level of 40 dS/m + water stress all the plants died so this treatment is not shown in the graph.

4. Discussion

4.1. Salinity and water stress effect on plant growth parameters

In many previous experiments the decrease in plant height has been studied. It was found that the reduction in plant height was due to salinity which decreased the plant growth by reduction in osmotic potential and deficiency of nutrients (Greenway and Munns, 1980). The closure of stomata and inactivation of enzymatic system occurred due to the decreased in internal and external osmotic potential which leads to decrease the plant growth. These all circumstances lead to reduction in CO₂ fixation and N assimilation which shorten the plant structure and decreased the plant height. The metabolic pathway is change by the accumulation of salts in cell wall; elasticity of cell wall decreased and ultimately reduced the plant height (Hameed *et al.*, 2010).

The effect of salinity varies with plant species, plant parts, stage of growth and development (Munns, 2002). Yaron *et al.* (1996) revealed that with increased in salinity stem diameter and leaf growth was reduced. The plants which possess less number of branches and leaves, they gain less weight and attain less stem diameter Ashraf and Sarwar (2002). Qadir *et al.* (1997) investigated that stem diameter was more decreased by salinity than sodicity. They also found that salinity and sodicity decreased the stem diameter in different plant species. The stem diameter decreased due to the reduction in turgor potential and division of cell (Ashraf *et al.*, 1999).

It was investigated by many scientists that with increased in salinity plant biomass was reduced (Ahmad, and Chang, 2002) (Khan *et al.*, 2009). Under salinity and drought physiological and biochemical activities were affected that results decreased the biomass production (Munns, 2002) this reduction in biomass production may be due to the decreased in number of leaves and their area. Biomass production have prime importance in salinity tolerance, plants which possess higher fresh weight said to be performed better under saline condition (Saqib *et al.*, 2004). The plant species said to be more salt tolerant which have ability to eliminate sodium from shoots and root. Under controlled condition the biomass production assessed the tolerance of plant against salinity. Under salinity due to osmotic effect the water potential of roots were decreased and growth embarrassment takes place as a results the shoot fresh weight of plants were decreased (Munns, 2002).

Salinity has an effect on root growth but here are few studies on root growth related to salinity. A large quantity of litter falls and fine roots of perennial plants affect physico- chemical properties of soils (Lal, 2001). The microbial populations in root zone were regulated by carbonaceous materials and organic substrates such as sugars, amino acids and organic acids, produced by plant roots. Tree roots produced carbon dioxide and roots also act as natural tillage tools which increased soil permeability. Sodium present on exchange sites was replaced by calcium which produced by Carbon dioxide when solubilized the lime (Robbins, 1986).

Perennial plants which possess long and deep rooting system they improve the soil structure within plow layer. Under saline condition which produced high amount of dry matter. Their survival rate was higher than others which produced low amount of dry matter (Khasa *et al.*, 2002). Plants grown under salinity could be catagories on the basis of Relative dry matter production for salinity tolerance. Cresswell and Kirkegaard (1995) investigated that porosity and permeability of soil could be increased by deep rooted crops. Salinity and sodicity of soils decreased by deep roots because it play role as bio drain.

4.2. Physiological parameters affected by salinity and water stress

Salinity and drought are most familiar abiotic stresses that effect plant growth and limit the many physiological processes such as photosynthetic rate, mineral distribution and membrane permeability (Qin *et al.*,

2010). Salinity decreased the photosynthetic rate of most of the plant species (Ashraf and Shahbaz, 2003). Yang *et al.* (2008) observed that net photosynthetic rate of plants decreased by the stomatal factors. Under saline condition salts were accumulate in older leaves and due to excess salts premature leaf senescence occurred and photosynthetic leaf area of a plant resultantly decreased the photosynthetic rate (Munns, 2002).

Stomata become closed under saline stress because turgor pressure decreased which leads to decrease the photosynthesis. In most fruit crops net photosynthesis rate and transpiration rate was decreased by salinity, this reduction in photosynthetic rate due to the closer of stomata. In saline soil CO₂ entrance into leaves was restricted which leads to decreased of photosynthesis rate in guava (Al-Dinar *et al.*, 1999). Salinity and drought decreased the soil water contents which reduced the soil water potential. Osmotic potential of soil is reduced by excess amount of salt in soil solution resultantly water stress created and plant unable to absorbed water which reduced leaf water potential and transpiration rate of plant is decreased (Munns, 2002). Under saline condition leaf turgor pressure is decreased as a result of decreased in leaf water potential. Salinity decreased the photosynthetic and transpiration because reduction in many physiological and morphological processes occurred, such as, stomatal opening, leaf tissues, leaf turgor potential (Jones and Turner. 1978).

Transpirational flux required for translocation of ions in roots and shoots which help to maintain the water status and regulated the transpiration rate in plants. When transpiration rate decreased which reduced the uptake of ions by roots, xylem conductivity decreased resultantly decreased the ions in leaves (Berstein *et al.*, 1995). Plants grown under saline soils were subjected to water stress and uptake of water by plants was decreased which ultimately decreased the transpiration rate (Munns, 2002).

Stomatal conductance of plants decreased by salinity and by the combined effect of salinity and drought because under stress roots of plant unable to uptake water from soil. This is the main process adopted by the plants under saline stress (Huang and Redmann, 1995). Under this condition an imbalance between uptake of water by roots and loss of water by transpiration occurred resultantly stomatal conductance decreased which leads to wilting of plant. Under saline and water stress plants closed its stomata which protect the plant from dehydration. However, closing of stomata also stop the exchange of carbon dioxide and oxygen between outside atmospheric air and its internal tissue. This condition decreased the uptake of nutrients by plant and slows down many metabolisms in plant and decreased the chances of plant survival (Tang *et al.*, 2002).

4.3. Effect of salinity and water stress on plant Na⁺ and K⁺ status

Under saline conditions plant salinity tolerance, survival and growth depends on many factors from which plant species was one of these factors. Growth of higher plants especially glycophytes was affected by overload of soluble salts in root zone (Raza *et al.*, 2006). Sodium and calcium concentration was higher but potassium concentration was decreased under saline stress. When concentration of Na⁺ increased in root zone of plants then concentration of K⁺ was reduced (Saqib *et al.*, 2004) the plant growth under salinity was stimulated by an enzyme name as Pectin-esterase. This enzyme function as change in apoplastic pH, de-esterify the pectin of the wall, change the environment of ions in plant and helps the pectin to combine with calcium to form gel. Pectin has ability to change the cell wall extensibility and promote growth under saline condition but the enzyme activity stopped by higher concentration of sodium (Nari *et al.*, 1991). The tuberous roots present in guava have ability to store water, mineral salts, and organic solutes which help to plant survive in saline and dry condition (Duarte *et al.*, 2004).

High concentration of sodium caused cytotoxicity and decreased the plant growth under saline condition. Translocation system of ion transport was disturbed by sodium ion when present in excess amount (Iqbal and Ashraf, 2007). Potassium present on exchange sites and in solution was replaced by Sodium results ion toxicity and due to greater uptake of Na⁺ osmotic pressure increased but water potential decreased (Diedhiou *et al.*, 2008). Nutritional imbalance caused in glycophytes by sodium results in toxicity of sodium (Akram *et al.*, 2007).

Mature leaves have high concentration of Sodium than younger leaves that increased the concentration of Na⁺ and Cl⁻ in leave tissues and ultimately decreased the yield of crops. Accumulation of salts in older leaves in saline soils leads to senescence of leaves and decreased photosynthetic leaf area resultantly plants growth reduced (Munns, 2002). Saline stress increased the Na⁺ concentration which reduced the K⁺ concentration resultantly enzymes activity was decreased because K⁺ was required for the activation of many enzyme (Willadino and Camara. 2005).

Potassium plays an important role in remediation of salt toxicity and osmotic stress (Shirazi *et al.*, 2005). Netondo *et al.* (2004) found that under salinity sodium was the major cation that accumulated in roots, this accumulation of sodium ion effected the concentration of K⁺ in plant. Under high saline condition potassium concentration in xylem was significantly decreased. Plant Roots membrane integrity loosed under high salinity and roots system of plant become leaky resultantly K⁺ efflux occurred. Usually, under salinity the root permeability of plant was decreased resultantly water uptake and uptake of nutrients were decreased.

Potassium has prime importance in plant metabolism. Potassium regulated the different process in plants and activates the many enzymes and involved in improvement of cell structure (Ashraf *et al.*, 2008).

Under saline condition plant need proper concentration of potassium for survival because it plays an important role to lower the osmotic potential within roots which necessary for turgor pressure that transport the solute and water in xylem. The accumulation of K^+ in roots decreased the concentration of chloride (Tavili and Biniaz, 2009).

Under saline condition competition between Na^+ and K^+ which results decreased concentration of potassium in leaves. An important physiological mechanism that helps to plants in salinity tolerance was the selective uptake of potassium ion which was opposed to sodium ion (Gupta and Srivastava, 1990). Wenxue *et al.* (2003) found that efficient and selective up take of k^+ by plants help in salinity tolerance. The high concentration of K^+ and low concentration of Na^+ in cytosol maintained by plants under the influence of salinity. Plant adapted the strategy to uptake more potassium and efflux more sodium from the cell and sodium used for osmotic adjustment in cytosol (Zhu, 2003).

5. CONCLUSION

In conclusion, it was observed that salinity and water stress reduced the growth of *Conocarpus erectus L.* and uptake of potassium. At T_8 (40 dSm^{-1} + water stress), plants did not survive. It is resulted that salinity and water stress collectively affect the growth, physiological and chemical parameters of *Conocarpus erectus L.* We concluded that *Conocarpus erectus L.* can tolerate salinity up to 40 dSm^{-1} with full water but at salinity and water stress level of 40 dSm^{-1} + water stress, there was no survival of even a single plant. Acknowledgement: Authors are very thankful to Dr Ghulam Abbas for their consistent and inspiring guidance and kind cooperation for accomplishing the research work.

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