Clone 4	0.013	0.04	0.021	0.014	0.032	0.02	0	0	0	0
Clone 5	0.081	0.0039	0.0053	0.0013	0.0026	0	0	0	0	0
Clone 6	0.0086	0.015	0.0073	0.055	0.02	0.01	6.5E-06	2.1E-06	0	0

Table 18: Effect of NaCl concentrations on tannin content (mg/g cladode) of C. *equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	17.55	18.17	18.71	19.25	21.94	17.6	0	0	0	0
Clone 2	16.25	16.94	17.17	20.4	21.25	16.33	0	0	0	0
Clone 3	21.94	22.25	22.79	23.02	24.32	20.85	3.01	1.48	0	0
Clone 4	21.79	22.48	24.32	24.86	26.56	21.45	0	0	0	0
Clone 5	23.86	25.09	26.56	27.09	27.94	22.66	0	0	0	0
Clone 6	21.79	22.79	23.56	27.32	28.94	20.59	14.09	15.32	0	0

Table 19: Effect of NaCl concentrations on nitrate reductase content (mg/g cladode) of C. *equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	5.37	5.27	5.46	5.05	4.5	4.98	0	0	0	0
Clone 2	5.47	5.59	5.41	6.16	5.48	5.38	0	0	0	0
Clone 3	5.31	4.45	5.31	5.47	5.58	5.25	0.32	0.5	0	0
Clone 4	5.72	6	6.34	5.31	5.4	4.96	0	0	0	0
Clone 5	6.87	6.77	7.5	6.76	6.49	5.96	0	0	0	0
Clone 6	7.31	6.76	7.03	6.31	5.6	6.75	0.68	0.72	0	0

Table 20: Effect of NaCl concentrations on phenol content (mg/g cladode) of C. *equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	0.52	0.6	0.01	0.005	0.14	0.52	0	0	0	0
Clone 2	0.63	0.81	0.53	0.19	0.12	0.59	0	0	0	0
Clone 3	0.92	0.51	0.03	0.38	0.52	0.83	2.22	2.84	0	0
Clone 4	1.92	1.99	1.9	1.97	1.8	1.52	0	0	0	0
Clone 5	0.76	2.66	1.97	2.03	1.91	0.69	0	0	0	0
Clone 6	2.83	2.53	2.43	2.4	2.43	2.76	4.67	4.5	0	0

Table 21: Effect of NaCl concentrations on proline content (mg/g cladode) of *C. equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	4.86	4.86	3.69	3.39	2.74	4.08	0	0	0	0
Clone 2	4.18	3.78	3.69	3.52	3.23	3.98	0	0	0	0
Clone 3	1.34	1.27	0.75	0.26	0.02	1.29	8.55	11.16	0	0
Clone 4	1.3	1.49	1.85	1.95	2.21	1.03	0	0	0	0
Clone 5	1	1.23	1.33	1.98	2.18	0.9	0	0	0	0
Clone 6	2.31	2.63	2.83	2.96	3.32	1.3	17.1	26.04	0	0

Table 22: Effect of NaCl concentrations on total carbohydrates content (mg/g cladode) of *C. equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	34.04	30.97	31.11	28.73	29.05	33.09	0	0	0	0
Clone 2	33.93	33.28	31.25	28.63	27.06	32.17	0	0	0	0
Clone 3	33.33	33	31.82	31.69	31.71	31.13	13.07	10.78	0	0
Clone 4	32.43	31.04	27.04	28.4	26.41	30.15	0	0	0	0
Clone 5	32.26	31.82	32.03	31.36	30.97	31.09	0	0	0	0
Clone 6	32.17	31.96	30.97	30.69	28.63	31.16	15.69	12.75	0	0

Table 23: Effect of NaCl concentrations on reducing sugar content (mg/g cladode) of *C. equisetifolia* cladodes.

Clones	Before NaCl treatment					After NaCl treatment				
	Control	100 mM	200 mM	300 mM	400 mM	Control	100 mM	200 mM	300 mM	400 mM
Clone 1	1.03	1.27	1.52	1.64	1.88	1	0	0	0	0
Clone 2	3.56	1.56	0.34	2.28	3.59	3.32	0	0	0	0
Clone 3	0.12	0.36	0.79	1.12	1.33	0.11	15.35	13.6	0	0
Clone 4	2.95	3.04	3.16	3.43	3.71	2.85	0	0	0	0
Clone 5	1.06	1.82	2.25	4.04	4.98	1.05	0	0	0	0
Clone 6	1	1.94	2.22	2.86	2.92	1	25.62	41.81	0	0

DISCUSSION

From the experiment it was clear that clone 3 and clone 6 were able to survive high saline conditions upto 200 mM concentration. Others clones showed mortality at the end of 40 days of salt treatment. Salinity adversely affects plant by inducing injury, inhibiting growth, altering in plants morphology and anatomy, often being a prelude to mortality [19]. It was supported by significant variations in root length, shoot length, total plant height and collar diameter. However the response on clone three was different compared to that of clone 6. Salinity inhibits vegetative growth of non-halophytes, with reduction of shoot growth more than root growth [20]. Through macroscopic observations, the cladode thickness was found to increase in a remarkable manner between the saline treated and non-treated clones. Clone 3 recorded an increase in thickness by an average of 0.77 mm when compared to the untreated while clone 6 to showed an increment in thickness by an average of 0.64 mm, thereby conferring modifications in plant morphology to adverse conditions. Leaves become thicker and more succulent. The great leaf thickness may reflect more layers of mesophyll cells, larger cells or both [21].

With regard to physiological parameters, the clone 4 ranked highest for sturdiness quotient and clone 1 ranked highest for Volume Index. Both clones 3 and 6 recorded only intermediate values for these physiological parameters supporting prevalence of growth constraints [22].

Anatomical study revealed distorted changes in cladode parenchyma emphasizing pressure exertion on the cells which could be due to increase in water accumulation to regulate osmosis [23-25].

Among the most cited studies related to anatomical modifications induced by salinity stress which could not detect differences in root diameter after 4 weeks of growth under saline conditions, but this author reported that salinity was associated with a greater number of small diameter xylem vessels. In contrast, Robert E found an increase in root diameter produced by salinity and suggested that a reduction in cell size, an increase in root diameter and a smaller plant size could be adaptive advantages for prolonged survival in saline or dry soils. Other workers increased suberization and thickening of the endodermis, which in turn resulted in an increase in the diameter of both the root and the vascular cylinder. With regard to the effect of salinity on stems, Plaza BM, et al., found that salinity retarded the differentiation of xylem and phloem elements while stimulating excessive growth of the cortex parenchyma cells. Unfortunately there are fewer studies on the effect of salinity on stems than on leaves and roots.

CONCLUSION

Biochemical study showed increasing trend for parameters such as free amino acids, phenols, praline content and reducing sugars. Whereas, there was a noticeable decline in proteins, anthocyanins, tannins, carbohydrates and nitrate reductase activity. However, it was observed that chlorophyll content did not face a drastic changes within the 40 days period of saline exposure. Remarkable variations for free aminoacid content, proline content and reducing sugars suggest them as dependable markers for screening saline tolerance in *Casuarina equisetifolia.*

In non-halophytes, salt induced inhibition of plant growth is accompanied by metabolic dysfunction, including decreased photosynthetic rate and changes in enzyme activity. In halophytes physiological activities may be stimulated or not altered by salt concentrations that are inhibitory in non-halophytes. Salinity decreases carbohydrates or growth hormones thereby inhibiting growth. High salt concentration inhibit enzymes by impeding the balance of forces controlling the protein structure. Salinity affects negatively the nutritional balance of the on Dalbergia sissoo tree indicated that the use of saline irrigation water decreased the contents of chlorophyll and carotenoids while a pronounced increase was noticed for praline, phenols and indole contents.

REFERENCES

1. Wang W, Vinocur B, Altman A. Plant responses to drought, salinity and extreme temperatures: Towards genetic engineering for stress tolerance. Planta. 2003;218(1):1-14.
2. Bates LS, Waldren RP, Teare ID. Rapid determination of free proline for water stress studies. Plant Soil. 1973;39:205-207.
3. Kalaji MH, Pietkiewicz S. Salinity effects on plant growth and other physiological processes. Acta Physiologiae Plantarum. 1993;15:89-124.
4. Pinyopusarerk K, House APN. Casuarina: An annotated bibliography. International center for research in agroforestry publishers. Nairobi, Kenya. 1993:298.
5. Sadasivam S, Manickam A. Biochemical Methods. 2nd edition. New age international publishers. Coimbatore. Tamilnadu, India. 1996:256.
6. Hatchell GE. In: Proc. Third B.C. South S.J. Ref. Conf. (Shoulders, E., Eds.). Attanta, G.A. Nov. 18. GTR 80-84. 1985:395-402.
7. Manavalan A. Seedling vigour and bio-productivity in woody biomass species. Ph.D.Thesis, Madurai Kamarajar University, Madurai. India. 1990:201.
8. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian council of agricultural research publishers. New Delhi, India. 1995:361.
9. Hedge JE, Hofreiter BT. Carbohydrate chemistry 17. Whistler, R.L. and Be Miller, J. N., Eds., Academic Press, New York. 1962.
10. Miller GA. Psychology: The science of mental life. Harper and Row Publications. Newyork. USA. 1962:252-253.
11. Lowry OH. Protein measurement with folin phenol reagent. J Biol Chem. 1951;193:265-275.
12. Moore S, Stein WH. Photometris ninhydrin method for use in the chromatography of amino acids. J Biol Chem. 1948;176:367-388.
13. Hagerman AE. Radial diffusion method for determining tannins in plant extracts. J Chem Ecol. 1987;13:437-449.
14. Arnon DI. Copper enzymes in isolated chloroplasts. polyphenol oxidase in beta vulgaris. Plant Physiology. 1949;24:1-15.
15. Malik, Singh. Plant enzymology and histo enzymology. Kalyani Publishers. New Delhi. India. 1980:286.
16. Robert EB. Method for estimation of tannin in grain sorghum. J Ser Pap. 1971;63(3):511-512.
17. Giusti MM, Rodriguez-sona LE, Wrolstad RE. Spectral characteristics, molar absorptivityand colour of perargonidin derivatives. J Agric Food Chem. 1999;47:4631-4637.
18. Plaza BM, Jimnez S, Segura ML, et al. Lao Institute of Agricultural and Fishing Investigation and Training (IFAPA), Junta of Andalusia, Almer a, Spain. Department of vegetal production, higher polytechnic college, Almeria, spain. 2006.
19. Kozlowski TT, Pallardy SG. Physiology of woody plants. 2nd Edition. Academic Press. San Diego, California. USA. 1997;2(40):168.
20. Azza Mazher AM, Zahloul M Sahar, Yassen AA. Response of dalbergia sissoo to sulphur application under saline condition. Am Eur J Agric Environ Sci. 2006;1:215-224.
21. Strogonov BP. Physiological basis of salt tolerance of plants. Israel program for scientific translations, Jerusalem publisher. Russian. 1964:256-279.
22. Neumann PM. Inhibition of root growth by salinity stress: Toxicity or an adaptive biophysical response. Kluwer academic publishers. Netherlands. 1995:299-304.
23. Shannon MC, Grieve CM, Francois LE. Whole plant response to salinity. Plant Environ Interact. 1994:199-244.
24. Azza Mazher AM, Fatma El-Quesni EM, Farahat MM. Responses of ornamental plants and woody trees to salinity. World J Agric Sci. 2007;3(3):386-395.
25. Glenn EP, Brown JJ, Blumwald E. Salt tolerance and crop potential of halophytes. Crit Rev Plant Sci. 1999;18:227-255.