

Influence of UV-B supplemental radiation on growth and pigment content in *Suaeda maritima* L.

K.C. RAVINDRAN, N. MAHESH KUMAR, V. AMIRTHALINGAM, R. RANGANATHAN,
K.P. CHELLAPPAN and G. KULANDAIVELU*

Department of Botany, Annamalai University, Annamalainagar-608 002, India

Department of Plant Sciences, Madurai Kamaraj University, Madurai-625 021, India*

Abstract

In a field experiment with a mangrove species *Suaeda maritima* L. grown under ambient and supplementary UV-B radiation corresponding to 20 % ozone depletion, changes in growth and contents of photosynthetic and UV-absorbing pigments were determined. Supplemental UV-B irradiation for 9 d significantly reduced the growth and concentration of photosynthetic pigments. However, anthocyanin and flavonoid contents were significantly increased in UV-treated plants and which could be reduce the UV-B penetration and damage to the underlying tissues.

Additional key words: anthocyanins, chlorophyll, flavonoids, mangrove.

Ozone absorbs appreciably radiation at wavelengths shorter than 300 nm (World Meteorological Organisation 1992). A reduction of the stratospheric ozone layer results in a very specific increases in short wavelength solar ultraviolet radiation (UV-B, 280 - 320 nm). Human activities have led to the increase of halogenated hydrocarbons causing a depletion of the stratospheric ozone layers. As a result of ozone loss, UV-B fluence at the surface of the Earth inevitably increases negative impacts on biological organisms (Coohill 1991). India lies in the low ozone belt and is expected to receive high flux of UV-B radiation, which may be damaging to plants (Mitra 1991). Mangrove forests are prime target of the tropical coast line for the world climatic changes and sea level rise. Impacts of increased UV-B on mangroves have not received much attention (Lovelock 1992). The aim of the present work was to study the effects of UV-B enhanced radiation on growth, as well as UV-absorbing and photosynthetic pigments of *Suaeda maritima* L.

Suaeda maritima L., annual species belonging to the family *Chenopodiaceae*, grows in abundance in the mangrove belt of Pichavaram (11°24'N and 79°44'E) north-east coast of India peninsula. One-month-old

healthy seedlings of uniform size were planted individually in polythene bags filled with garden soil containing red earth, sand and farmyard manure (1:2:1). UV-B radiation was provided for 6 h (10:00 - 16:00) by *Philips* TL 20W/12 sun lamps (*N.V. Philips*, Gloelampenfabriek, The Netherlands). The daily UV-B irradiance ($12.2 \text{ kJ m}^{-2} \text{ d}^{-1}$) was equivalent to that anticipated with 20 % stratospheric ozone depletion at study site Pichavaram mangrove forest. Radiation below 280 nm was completely removed using cellulose-diacetate filter.

Shoot length and fresh mass of the seedlings were determined soon after the seedlings were uprooted. Leaf area was measured using a *LI-3100* leaf area meter (*Li-Cor*, Lincoln, USA). The dry mass of the seedlings was determined after they had been dried for 24 h at 80 °C. Photosynthetic pigments were extracted in N,N-dimethyl formamide and chlorophyll was estimated by the method of Moran and Porath (1980) using the formula suggested by Inskeep and Bloom (1985). Carotenoid content was estimated according to Ikan (1969). Anthocyanins were extracted from leaves and assayed following the method of Mancinelli *et al.* (1975)

Received 9 October 2000, accepted 7 December 2000.

Abbreviations: Car - carotenoids; Chl - chlorophyll; UV-B - ultraviolet B (280 - 320 nm) radiation.

Fax: (+91) 4144 38145, e-mail: drchellappan@usa.net

and flavonoids were estimated following the procedure of Mirecki and Teramura (1984). Protein concentration was determined by the method of Lowry *et al.* (1951).

About 64.2 % reduction in fresh mass, 77.5 % reduction in dry mass, 12.9 % reduction in shoot length and 62.2 % reduction in leaf area were noticed in UV-B treated seedlings on the 9th day of treatment (Table 1). Lingakumar and Kulandaivelu (1993) found a 15 % reduction in shoot length of *Vigna unguiculata* when exposed to UV-B radiation for short duration. UV-B retarded the shoot elongation and also leaf expansion to a great extent (Vu *et al.* 1978). In cucumber, leaf expansion was reduced by 60 - 70 % (Tevini *et al.* 1981), which was in agreement with our observation.

On fresh mass basis total chlorophyll (Chl) content was reduced nearly 62.7 % when compared to control seedlings on the 9th day of treatment (Table 2). Reduction in Chl *a* and Chl *b* contents might be due to inhibition of biosynthesis or due to degradation of Chl and their precursors (Teramura 1983). Similar reduction in Chl content in *Vigna sinensis* under enhanced UV-B radiation was observed (Kulandaivelu *et al.* 1989). The carotenoid (Car) content was found to be reduced nearly to 60.8 % in treated plants when compared to control seedlings. Several reports have suggested a reduction in carotenoids following UV-B exposure (Tevini *et al.* 1981, Premkumar and Kulandaivelu 1996). Carotenoids protect Chl from photooxidative destruction (Middleton and Teramura 1993).

Table 1. Effect of supplemental UV-B radiation on shoot length, leaf area, fresh mass and dry mass of *Suaeda maritima* L. Means \pm SE of 10 replicates. All the values are significant at $P \leq 0.05$.

Time [d]	UV-treatment	Shoot length [cm plant ⁻¹]	Leaf area [cm ² plant ⁻¹]	Fresh mass [g plant ⁻¹]	Dry mass [g plant ⁻¹]
3	control	20.01 \pm 3.4	5.50 \pm 0.14	2.30 \pm 0.04	0.40 \pm 0.02
	UV	19.57 \pm 2.8	5.00 \pm 0.11	1.70 \pm 0.02	0.35 \pm 0.05
6	control	22.35 \pm 2.2	7.10 \pm 0.22	2.50 \pm 0.06	0.52 \pm 0.10
	UV	20.85 \pm 2.5	4.20 \pm 0.18	1.50 \pm 0.03	0.30 \pm 0.17
9	control	25.12 \pm 3.2	9.50 \pm 0.45	2.80 \pm 0.08	0.80 \pm 0.08
	UV	21.87 \pm 3.5	3.30 \pm 0.27	1.00 \pm 0.05	0.18 \pm 0.05

Table 2. Effect of supplementary UV-B radiation on contents of Chl *a*, Chl *b*, Car [g kg⁻¹ (f.m.)], anthocyanins [A₅₃₀ g⁻¹(f.m.)], flavonoids [A₃₁₅ g⁻¹(f.m.)] and proteins [g kg⁻¹(f.m.)] in *Suaeda maritima*. Mean \pm SE of 10 replicates. All the values are significant at $P \leq 0.05$.

Time [d]	UV-treatment	Chl <i>a</i>	Chl <i>b</i>	Car	Anthocyanins	Flavonoids	Proteins
3	control	3.18 \pm 0.07	1.31 \pm 0.27	0.15 \pm 0.08	0.15 \pm 0.07	5.93 \pm 0.14	4.98 \pm 0.58
	UV	1.83 \pm 0.12	1.20 \pm 0.31	0.13 \pm 0.12	0.31 \pm 0.08	9.94 \pm 0.40	4.56 \pm 0.46
6	control	3.30 \pm 0.47	1.77 \pm 0.15	0.19 \pm 0.06	0.20 \pm 0.05	6.40 \pm 0.29	5.34 \pm 0.31
	UV	1.65 \pm 0.42	0.98 \pm 0.21	0.11 \pm 0.04	0.41 \pm 0.02	13.59 \pm 0.17	3.45 \pm 0.48
9	control	3.72 \pm 0.21	2.15 \pm 0.26	0.23 \pm 0.12	0.21 \pm 0.09	6.84 \pm 0.57	6.23 \pm 0.81
	UV	1.22 \pm 0.17	0.47 \pm 0.19	0.09 \pm 0.08	0.57 \pm 0.11	15.72 \pm 0.61	2.82 \pm 0.54

Nearly 171.4 % increase in anthocyanin content was found in UV-B treated seedlings after 9 d. In *Vigna unguiculata* over 136 % increased anthocyanin content was observed (Balakumar *et al.* 1993). Accumulated anthocyanins under enhanced UV-B in many plant species have only weak absorption in the UV-B region and therefore may be regarded as UV-screens only at very high concentrations (Pal *et al.* 1995). Flavonoid concentration was also significantly increased (129.8 %) under UV-B radiation. In *Rhizophora apiculata*,

increased accumulation of flavonoids was observed with reference to increased UV-B radiation (Moorthy and Kathiresan 1997).

UV-B treated seedlings showed 54.7 % reduction in protein content when compared to control seedlings (Table 2). Leaf soluble protein content was affected in many of the crops tested for UV-B sensitivity (Teramura 1983). Vu *et al.* (1982) stated that increased leaf protein could be traced only during early leaf development, but decreased thereafter.

References

Balakumar, T., Vincent, V.H.B., Paliwal, K.: On the interaction of UV-B radiation (280 - 315 nm) with water stress in crop plants. - *Physiol. Plant* **87**: 217-222, 1993.

Coohill, T.P.: Stratospheric ozone depletion as it affects life on Earth - the role of ultraviolet action spectroscopy. - In: Abrol, Y.P., Wattal, P.N., Gnanam, A., Govindjee, Ort, D.R., Teramura, A.H. (ed.): *Impact of Global Climatic Changes on Photosynthesis and Plant Productivity*. Pp. 3-21. Oxford & IBH Publishing Co., New Delhi 1991.

Ikan, R.: *Natural Products. A Laboratory Guide*. - Academic Press, New York 1969.

Inskeep, W.P., Bloom, P.R.: Extinction coefficients of chlorophyll 'a' and 'b' in N,N-dimethyl formamide and 80 % acetone. - *Plant Physiol.* **77**: 483-485, 1985.

Kulandaivelu, G., Maragatham, S., Nedunchezian, N.: On the possible control of ultraviolet-B induced response in growth and photosynthetic activities in higher plant. - *Physiol. Plant.* **76**: 398-404, 1989.

Lingakumar, K., Kulandaivelu, G.: Changes induced by ultraviolet-B radiation in vegetative growth, foliar characteristics and photosynthetic activities in *Vigna unguiculata*. - *Aust. J. Plant Physiol.* **20**: 299-308, 1993.

Lovelock, C.G., Clough, B.F., Woodrow, I.W.: Distribution and accumulation of ultraviolet radiation absorbing compounds in leaves of tropical mangroves. - *Planta* **188**: 143-154, 1992.

Lowry, O.H., Rosenbrough, N.J., Farr, A.L., Randall, R.J.: Protein measurement with the Folin phenol reagent. - *J. biol. Chem.* **193**: 265-275, 1951.

Mancinelli, A.L., Jang, C., Lindquist, P.P., Anderson, D.R., Rabino, I.: Photoregulation of anthocyanin synthesis - III. The action of streptomycin on the synthesis of chlorophyll and anthocyanin. - *Plant Physiol.* **55**: 251-257, 1975.

Middleton, E.M., Teramura, A.H.: The role of flavonol glycosides and carotenoids in protecting soybean from ultraviolet-B damage. - *Plant Physiol.* **103**: 741-752, 1993.

Mirecki, R.M., Teramura, A.H.: Effects of ultraviolet-B irradiance on soybean V. The dependence of plant sensitivity on the photosynthetic photon flux density during and after leaf expansion. - *Plant Physiol.* **74**: 475-480, 1984.

Mitra, A.P.: Global change and Indian experience. - In: Abrol, Y.P., Wattal, P.N., Gnanam, A., Govindjee, Ort, D.R., Teramura, A.H. (ed.): *Impact of Global Climate Change on Photosynthesis and Plant Productivity*. P. 17. Oxford & IBH Publishing Co., New Delhi 1991.

Moorthy, P., Kathiresan, K.: Influence of ultraviolet-B radiation on photosynthesis and biochemical characteristics of a mangrove *Rhizophora apiculata*. - *Photosynthetica* **34**: 465-471, 1997.

Moran, R., Porath, D.: Chlorophyll determination in intact tissues using N,N-dimethyl formamide. - *Plant Physiol.* **65**: 478-479, 1980.

Pal, M., Sharma, A., Sengupta, U.K.: Effect of UV-B radiation on germination and seedlings growth in mungbean (*Vigna radiata* L. Wilczek). - *Indian J. Plant Physiol.* **28**: 293-297, 1995.

Premkumar, A., Kulandaivelu, G.: Influence of ultraviolet-B enhanced solar radiation on growth and photosynthesis of potassium deficient cowpea seedlings. - *Photosynthetica* **32**: 521-528, 1996.

Teramura, A.H.: Effects of ultraviolet-B radiation on the growth and yield of crop plants. - *Physiol. Plant.* **58**: 415-427, 1983.

Tevini, M., Iwanzik, W., Thoma, U.: Some effects of enhanced UV-B radiation on the growth and composition of plants. - *Planta* **153**: 388-394, 1981.

Vu, C.V., Allen, L.H., Jr., Garrard, L.A.: Effects of supplemental ultraviolet radiation (UV-B) on growth of some agronomic crop plants. - *Soil Crop Sci. Soc. Florida Proc.* **38**: 59-63, 1978.

Vu, C.V., Allen, L.H., Jr., Garrard, L.A.: Effects of supplemental UV-B radiation on primary photosynthetic carboxylating enzymes and soluble proteins in leaves of C₃ and C₄ crop plants. - *Physiol. Plant.* **55**: 11-16, 1982.