CHLOROPHYLL FLUORESCENCE PARAMETERS AND CHLOROPHYLL CONTENT IN MANGROVE SPECIES GROWN IN DIFFERENT SALINITY

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Summary. Leaf chlorophyll fluorescence parameters as well as chlorophyll content were compared in three dominant mangrove species grown in two zones with different salinity in the Bhitarakanika National Park. The accumulation of dry matter and chlorophyll content in leaves decreased under high saline conditions. Quantification and de-convolution of chlorophyll fluorescence transient into several phenomenological and biophysical parameters (JIP-test) revealed that maximum fluorescence (Fm), maximum quantum yield of primary photochemistry (Fv/Fm), area above the fluorescence curve between Fo and Fm, electron transport and active reaction centers per cross section decreased in the leaves of all species at high saline ambience compared to the low salinity zone. In contrast, a significant increase in the minimal fluorescence (Fo) was noticed in the leaves of *A. officinalis* and *H. fomes* in the highly saline zones. Among the fluorescence parameter studied, the area above the fluorescence curve between Fo and Fm was found to be more sensitive to salinity. Thus, salinity induced functional alterations in PS II and led to down-regulation of PS II activity.

Key words: chlorophyll fluorescence, mangroves, photosynthesis, salinity.

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INTRODUCTION

Bhitrakanika mangrove wetland is one of the important mangrove genetic resources of the world (Swaminathan, 1994) located in the estuarine environment, created by Brahmani - Baitarani river systems. It lies between 20^o 4′ and 20^o 8′ N latitude and 86^o 45′ and 87^o 5′ E longitude covering an area of 650 km^2 (Choudhury, 1990). In recent years many of the mangrove wetlands receive very limited amount of fresh water due to multifarious upstream water management programs that increase the salinity of soil and water leading to disappearance of salt sensitive species and also reduction in growth and reproduction (Spadling et al., 1997). The effect of salinity on the photosynthesis of mangroves has been studied to some extent mostly in relation to transpiration and stomatal conductance. Ball and Farquhar (1984) found that depression of carbon assimilation could be attributed to a reduction in stomatal opening. Since plant growth represents the balance sheet of photosynthesis, it can be expected that whatever effect of salinity on this process will be reflected in plant growth (Takemura et al., 2000). Little attention has been paid to the impact of salinity on photosynthesis and growth of mangroves. Hence, the objective of the present study was to investigate the functional alternation of photosynthetic apparatus (PS II) in mangroves in response to high salinity.

MATERIALS AND METHODS

The experiments were conducted with three dominant mangrove species (*Avicennia officinnalis, Heritiera fomes* and *Excoecaria agallocha*) from two different saline zones of Bhitarakanika wild life sanctuary, Orissa, India. The water and sediment salinity of the low salinity zone (LS) were 5.8±1.2 g/l and 0.3±0.01 %, respectively whereas for the high salinity zone (HS) they were 28.5±2.5 g/l and 1.2±0.1%, respectively during the investigation period.

Chlorophyll fluorescence was measured on fully expanded healthy leaves of five plants from each species using a plant efficiency analyzer (Hansatech Instrument Ltd, Norflok, U.K.) All measurements were done *in vivo* on fully dark-adapted attached leaves. From the fast O-J-I-P transients several bio energetic parameters were derived according to the equation of JIP-test (Strasser and Strasser, 1995; Strasser and Tsimilli-Michael, 2001). Leaf chlorophyll content was measured spectrophotometrically according to Porra (2002). After measurements of chlorophyll fluorescence the same leaves were collected and oven dried at 72^o C for 48h and the dry weight was measured.

RESULTS AND DISCUSSION

Bhitrakanika mangrove wetland harbors 65 species of mangroves and their associates, among which *Avicennia officinalis, Heritiera fomes and Excoecaria agallocha* are the dominant species found in all localities of the sanctuary (Choudhury, 1990). It has been observed that the growth pattern of these plants vary with tidal amplitude along with soil and water salinity.

Leaf dry matter and chlorophyll

Though mangroves are able to colonize in saline habitats, the accumulation of dry matter measured in the leaves was reduced in the three species of mangroves from the high salinity zone as compared to the low salinity zone (Table 1). Although the mechanism is not clear, it could be the result of the suppression of photosynthesis due to increased salinity, high concentration of ion accumulation, the cost of maintaining osmo-regulation and compatible solute production (Yeo, 1983). In the present study, high salinity did not affect significantly leaf chlorophyll content of mangroves. A slight decrease was observed in the three species from the high salinity zone as compared to the low salinity zone (Table 1).

Chlorophyll Fluorescence

Analysis of chlorophyll fluorescence parameters of mangrove plants showed an increase of the minimum fluorescence (Fo) in HS compared to LS zone (Fig.1A). In *A. officinallis* and *H.fomes* the increase of Fo was 37% and 31%, respectively whereas in *E. agallocha* it was only 5%. The increase of Fo is related to PS II inactivation and photoinhibition (Zlatev and Yordanov, 2004) and is possibly due to the reduced plastoquinone accepter (Q_A-) unable to be oxidized completely because of electron flow retardation through PS II (Krause and Weis, 1991).

The maximum fluorescence (Fm) was found to decrease in the three species under high salinity conditions (Fig.1B). The decrease in Fm in *E. agallocha*, *A. officinnalis* and *H. fomes* was 36%, 24% and 10%, respectively. The decrease in Fm

Table1. Changes of leaf chlorophyll content and leaf dry matter in three mangrove species grown in two zones with different salinity. Data represent the mean ± SD. LS - low salinity zone; HS - high salinity zone.

Species	Chlorophyll content (mg g^{-1}FW)		Leaf dry matter (%)	
	LS	HS	LS	HS
Excoecaria agallocha	2.8±0.2	2.4±0.8	69±2.5	58±1.5
Avicennia officinalis	2.7±0.1	2.5±0.3	56±1.3	51±1.5
Heritera fomes	2.5±0.2	2.2±0.2	61±3.5	53±1.6

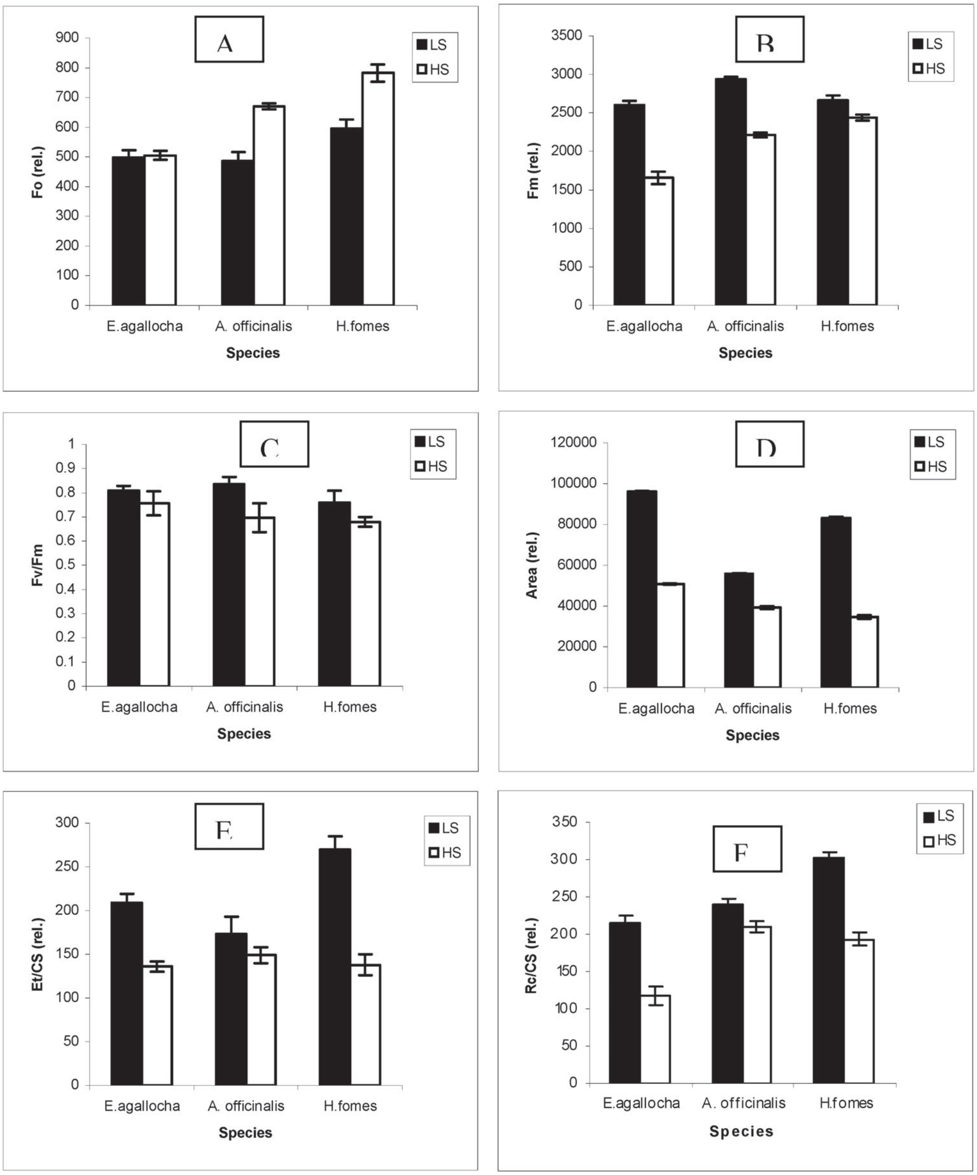

Fig.1. Changes of chlorophyll fluorescence parameters in mangrove leaves of three species grown in two zones with different salinity. Vertical bars represent the standard deviation. LS - low salinity zone; HS - high salinity zone; Fo - minimum level of fluorescence at 40 μs; Fm - maximum fluorescence; Fv - variable fluorescence (Fm-Fo); Fv/Fm - potential photochemical activity of PSII; area - the region above the fluorescence curve between Fo and Fm; Et/CS - electron transport per cross section; RC/CS - active reaction center per cross section.

may be related to the decrease in the activity of the water splitting enzyme complex and perhaps a concomitant cyclic electron transport within and around PS II (Aro et al., 1993). The maximum photochemical efficiency of PS II, so-called Fv/Fm ratio, also decreased slightly in the three species in HS conditions as compared to LS. The decrease was 6%, 16% and 10% in *E. agallocha, A. officinalis* and *H. fomes*, respectively (Fig.1C). A decrease in this parameter indicates either down-regulation of PS II or photoinhibition (Krause and Weis, 1991). The area above the fluorescence curve between Fo and Fm is proportional to the pool size of the electron acceptor Q_A on the reducing side of PS II which was highly sensitive to salinity (Fig.1D). The fall in the area under high salinity was maximum in *H. fomes* (58%) followed by *E. agallocha* (47%) and *A. officinnalis* (29%) as compared to low salinity conditions. The decrease in this value is due to the fall in the concentration of the acting electron acceptor of PS II. The electron transport per cross section (Et/CS) decreased in all three species at high salinity conditions as compared to low salinity. The decrease in this parameter is higher in *H. fomes* (48%) followed by *E. agallocha* (34%) and *A. officinalis* (13%). The active reaction center per cross section decreased in high salinity conditions in *E. agallocha*, *H. fomes* and *A. officinalis* by 45%, 36% and 12%, respectively.

The results presented here clearly demonstrated that an increase in salinity can reduce the growth and dry matter accumulation in mangrove leaves. In addition, salinity induced alterations in PS II and led to down-regulation of PS II activity as evidenced by the chlorophyll fluorescence data.

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