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EFFECTS OF THE EXPECTED SEA LEVEL RISE ON *AVICENNIA MARINA* L:A CASE STUDY IN QATAR

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تأثير ارتفاع مستوى سطح البحر المرتقب على نبات القرم

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أجريت هذه الدراسة بهدف تقديم معلومات أولية عن تأثير الغمر الناتج عن ارتفاع مستوى سطح البحر المرتقب على بادرات نبات القرم «افسينيا مارينا» . وقد أوضحت النتائج أن للغمر تأثير على العلاقات المائية والعمليات الأولية للبناء الضوئي في بادرات النبات قيد الدراسة . تمثل هذا التأثير جلياً في غلق الثغور ، وفقد المكون المتغير لكيناتيكيات طيف اللصف الكلوروفيلي ، وانخفاض الجهد المائي للأوراق . هذا وقد أفاد التحسن السريع في حالة النبات عند انهاء حالة الغمر المفروضة بأن للنبات قدر من التأقلم للتأثيرات المجهدة المصاحبة للغمر .

لذلك يعتقد ان الارتفاع المرتقب لسطح البحر نتيجة للاحترار العالمي وما قد يصاحب هذا الارتفاع من ارتفاع معدل الترسيب في بيئة نبات القرم قد تؤدي بهذا النبات إلى النمو في مساحات جديدة في مناطق ما فوق المد والجذر بمنطقة الذخيرة شمال شرقي دولة قطر .

Key Words: Flooding, Sea level rise, Mangrove

ABSTRACT

A simulation of the expected sea levels rise was carried out by imposing a state of protracted flooding on seedlings of the mangrove species *Avicennia marina* L. under natural conditions. The imposed flooding resulted in stomatal closure, loss of the variable component of prompt chlorophyll flourescence induction kinetics, and a slight reduction of leaf water potential. However, signs of fast recovery were observed after the period of flooding. The results indicated that *A. marina* possessed a certain degree of tolerance of metabolic functions to flooding. It is suggeted that sea level rise may favour survival of this mangrove species by provoking colonization of new supratidal flats at the study site

INTRODUCTION

The possible influence of the increased green house effect on sea level has gained a worldwide attention due to the alarming predictions produced by computer models. Human activities caused sea level to rise at an approximate rate of 1,2 mm year $^{-1}$ [1]. This observed sea level rise parallels the recorded global changes of temperature and increase tropospheric CO_2 concentrations [2]. Moreover, the expected flooding of coastal lines is known to result in an array of complicated metabolic disorders in plants that would eventually lead to alteration of growth [3], and bear serious implications for the zonation of coastal vegetation [4]. Mangroves are of particular importance among plant species inhabiting low-lying coastal areas due to their role in increasing estuarine productivity, controlling coastal erosion, and contributing towards the global carbon budget [5].

Dominance of the eurythermal and euryhaline *A.marina* L. mangrove in the Arabian Gulf reflects the high salinity and extreme water temperatures associated with this region [6]. This mangrove species is subject to semi-diurnal tidal flooding in waterlogged swamps with strong reducing conditions at the intertidal zone along the coastal line north-east of Qatar [7,8]. Work described in this paper was designed to present a simulation of the expected sea level rise accomplished by imposing a state of protracted flooding on *A.marina* under natural conditions. Experiments were carried out to provide preliminary information about the effects of protracted flooding on some aspects of water relations and photosynthesis in this mangrove species.

MATERIALS AND METHODS

Seedlings of *Avicennia marina* L. (approx. one-year-old) were chosen for uniformity at Al-Dhakhira north-east of Qatar. Pairs of seedlings were carefully transferred together with 2.0 kg of soil to plastic pots. Extreme care was taken to keep the root system in an intact undamaged condition. Pots were taken to the Department of Botany Experimental Grounds (University of Qatar) where they were left to stabilize under natural conditions in pools filled with sea water, and were observed for a month. Water in the pools was adjusted to inundate the waterlogged soil in the pots to mimic the siutation in the field. An air bubbling line was introduced into all pools to maintain adequate aeration. Water in the pools was replaced by sea water freshly brought from the Gulf at three-day intervals. For flooding experiments, levels of sea water in the pools were raised so as to cause complete flooding of the entire shoot system in order to simulate the situation during high tide in the field that may reach a depth of 1.5 m [9]. Flooding stress was then imposed for 14 days.

Stomatal resistance was measured using an automatic diffusion promoter (MK II, Delta-T Devices, Cambridge, UK). Values of stomatal conductance were calculated as 1/resistance [10]. Leaf water potential (ψ leaf) was measured using C-52 Sample Chamber and HR-33 Microvoltmeter (Wescor, Logan, Utah, USA) as previously described [11]. The maximal rate (F_R) of the induced rise in prompt chlorophyll flourescence induction kinetics [12] was measured using an SF-20 Plant Productivity Flouremeter (Richard Branker, Ottawa, Canada). All measurements were made at midday before, during, and after flooding, and were routinely repeated and standard error values were calculated.

RESULTS

Flooding of the shoot system of *A.marina* resulted in a marked reduction of stomatal conductance after one day of flooding (Fig. 1a). Flooding also resulted in a sharp decline in the value of the maximal rate of the induced rise in chlorophyll flourescence (F_R) induction kinetics (Fig. 1 b). This decline of prompt chlorophyll flourescence appeared two days after the onset of flooding, and the value of FR reached a minimum after eleven days (Fig. 1b). However, leaf water potential (ψ leaf) remained more or less unchanged for about three days under flooding, and showed a slight decline during the following ten days of the imposed flooding (Fig. 1c). Flooding-induced changes in both stomatal conductance and F_R recovered faster than leaf, and their values attained levels comparable to those of unflooded control plants.

DISCUSSION

Soil inundation has early been reported to affect plant water relations by inducing changes in stomatal behaviour, transpiration, water absorption, and leaf turgidity [13], and stomatal closure has been considered the earliest sign of flooding stress in plants [14,15]. Results of the present study demonstrated that stomatal closure appeared to be one of the signs of flooding stress in *A. marina* (Fig. 1a). This flooding-induced stomatal closure has previously been attributed to the effects of abscisic acid in the leaves [3], and/or loss of guard cell turgor [16].

Chlorophyll flourescence is a powerful probe for the study of photosynthesis, and the versatility of its application has added more validity to using flourescence techniques in stress physiology [17]. Changes in chlorophyll flourescence induction kinetics have successfully been used to assess stress-induced damaged to the photosynthetic apparatus [12,18,19,20]. Loss of prompt chlorophyll flourescence induction kinetics reported in this study in flooded *A. merina* (Fig. 1b) has previously been attributed to inhibition of photosynthesis at the level of the electron transport chain [19]. It has also been reported in the literature that photosynthesis of flooded plants appears to be reduced due to reduced ribulose bisphosphate regeneration [21], and reduced photosynthetic capacity [22]. It is, therefore, suggested that flooding-induced stress involved inhibition of gas exchange by induction of stomatal closure, and inhibition of the primary processes of photosynthesis.

Moreover, the delayed effects of flooding on (ψ leaf), and the fast recovery of all measured paramaters after the flooding period perhaps reflect the presence of a certain degree of adaptation of metabolic functions of *A. marina* to flooding stress. The results also suggest that the expected sea level rise together with an increased rate of sedimentation as a source of substratum may favour survival of *A. marina* by promoting its colonization of new areas in the supratidal zone present at Al-Dhakhira north-east of Qatar.

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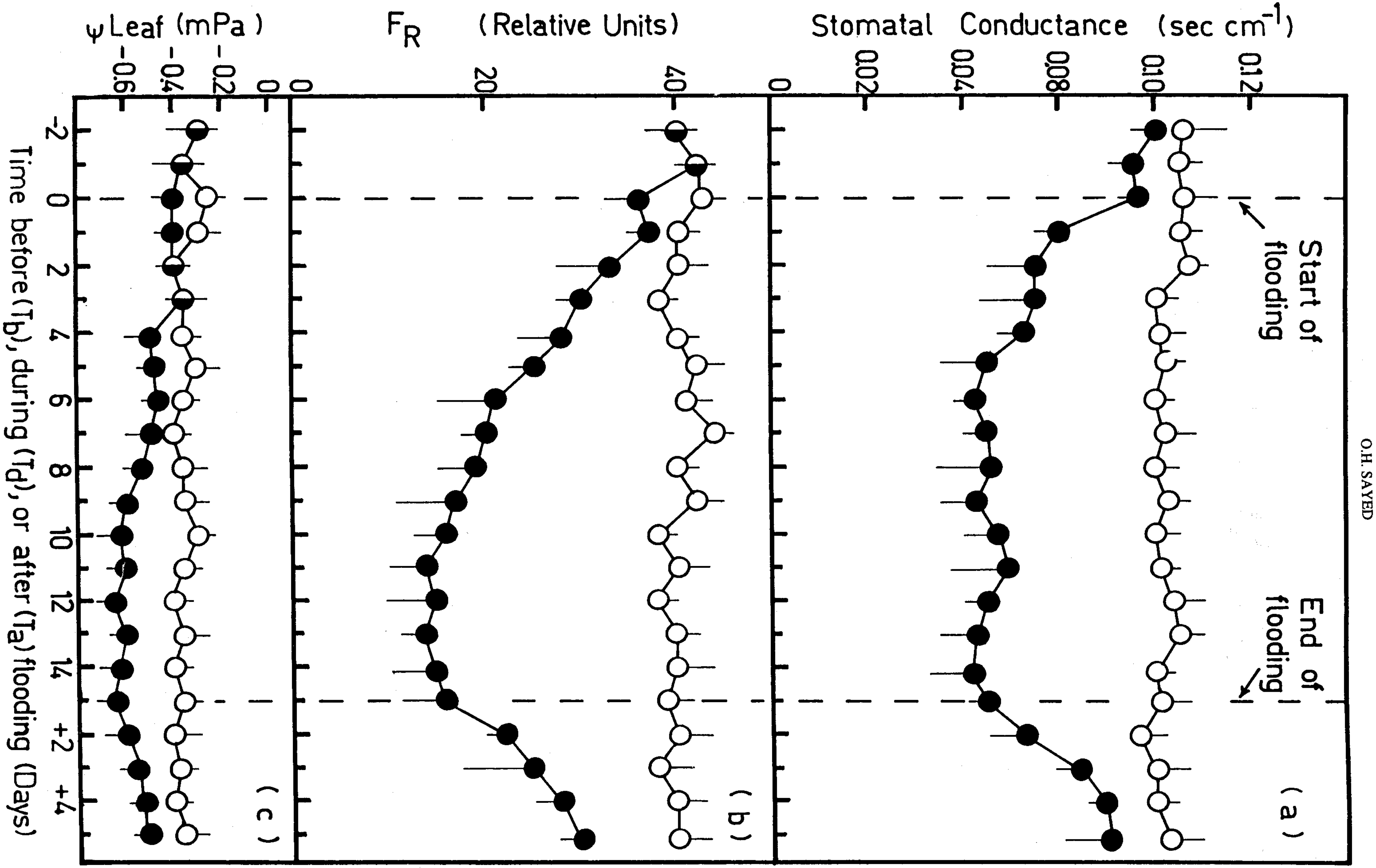

Fig.1. Effects of flooding on stomatal conductance (a), the maximal rate of the induced rise in chlorophyll fluorescence induction kinetics (b), and leaf water potential (c) of unflooded (white-circled lines), and flooded (Black-circled lines) seedlings of *A.marina*. (± SE, n=5). Time before flooding (Tb), time during flooding (Td), and time after flooding (Ta).

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