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Micronutrient Contents of *Heritiera fomes* Species at Three Saline Zones of the Sundarban Mangrove Forest, Bangladesh

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Abstract

Micronutrient or essential heavy metals *viz.* Copper (Cu), Zinc (Zn) and Iron (Fe) distribution trend were studied at the age of 6, 9 and 30 months old *Heritiera fomes* seedlings at three distinct saline zones *viz.* Chandpai (Oligohaline), Jungra (Mesohaline) and Munshiganj (Polyhaline) of the Sundarban mangrove forest. Among the observed micronutrients, Fe content comparatively lower than Cu and Zn. Relatively higher Cu was found in the root of 6 month age *Heritiera fomes* seedlings grown at the Chandpai (Oligohaline) zone but higher content of Zn was found in the both root and the shoot. At the 9 month age, comparatively higher content of Cu was found in the root of the seedlings grown at the Jungra (Mesohaline) zone but in the shoot, comparatively higher Cu content was observed in the seedlings grown at the Munshiganj (Polyhaline) zone. At the age of 30 months, Cu and Zn both contents found comparatively lower. At the same age (30 months) Fe content was found relatively higher in the root and the shoot of *H. fomes* seedlings grown at Chandpai saline (Oligohaline) zone but lower in 6-month-old seedlings. At the older age seedlings may appear more metal tolerant/avoider than the younger age seedlings.

Subject Areas

Biotechnology, Ecosystem Science, Edaphology, Environmental Sciences

Keywords

The Sundarban, Micronutrient, Copper, Zinc, Iron, Oligohaline, Mesohaline, Polyhaline

1. Introduction

The Sundarban is an important tidal mangrove forest from both ecological and economic viewpoints. The forest stands over Ganges basin and playing an outstanding role in balancing the coastal wetland ecosystems in the Bengal basin [1]. The Sundarban covering 10,000 square kilometers of land and water, is part of the world's largest delta (80,000 sq.km) formed from sediments deposited by three great rivers the Ganges, Brahmaputra and Meghna, which covered on the Bengal Basin. About 62% of the Sundarban lies in the Khulna region of the south western part of Bangladesh, while the remaining 38% is in India (Lacerda 2001). So, the total area of the Bangladesh Sundarban is 6017 km^2, of which 4016 km^2 is forest land and the balance is covered by water [2].

Heritiera fomes is a prominent less saline habitat species of the Sundarban mangrove forest. It is more widespread in south Asia and grows exclusively in tidal areas with large stands or grove which reflected their own ecological community. The natural vegetation of the Sundarban mangrove forest depends on natural regeneration. Although mangroves inhabit in different level of saline sediments, their growths generally decline with increasing sediment salinity [3]. Extremely high salinity negatively influences the growth of mangroves seedlings [4]. Based on extensive studies on previous findings in different mangrove seedlings showed the variations on adaptation and respond positively to moderate salinity but negatively influenced by excessive salinity [5]. Now a day as a genus *Heritiera* is in a threatened category. Due to environmentally induced mortality declines *Heritiera fome* has been recorded in many parts of the forest [6] [7] [8]. Various abiotic stresses reduce their survival rate through both ionic toxicity and osmotic stress. Since a complex range of interacting abiotic and biotic factors control the availability of nutrients to mangrove species [9].

Micronutrients or some heavy metals like Fe, Cu, Zn, Mn, B, Mo and Cl are required in small amount and their content in plant components are influenced the metabolic requirements but presence of insufficient and excessive of such micronutrients poses various stresses on plant growth and metabolism [10] [11] [12], and exhibit nutrient stress or toxicity [13]. Fine textured anoxic mangrove sediments are highly efficient and effective sinks for a variety of heavy (trace) metals in which colloidal particles in the sediment scavenged from the water [14]. These underlying sediments, often creating problems of trace metal contamination of sea water and biota. Through mentioned metals (Cu, Fe, Mn, Ni, and Zn) are essential as micronutrient for plants [15] but their excessive presence indicated a high level of metal pollutions in the many mangrove habitats [16]. Since heavy metal concentrations occasionally exceed the EQS (Environment Quality Standard) limit [17]. While exceeded the EQS, deposition of heavy metal like Pb, Zn, Cu, and Cd can be absorbed by plants and maybe led to massive tree mortality [18]. However, growth of mangrove seedlings showed more sensitivity to these heavy metals (Pb, Cd, Cu, Fe, etc.). On the other hand, excessive absorption of individual ions may toxic to the early stages of plants or may retard the absorption of other essential plant nutrients.

The critical stages of the mangrove species are seed germination and survival which completely depends on its physical nature and environmental characteristics [19]. During seed germination and early growth, seedlings depend upon minerals stored in the seed for development, and upon depletion of this source plants become dependent on soil minerals. So, Nutrient availability is one of the major factors influencing mangrove forest structure and productivity. Mangroves usually found to cope with low nutrient availability [20]. Because they usually thrive in saline environment and copped various mechanisms such as selective ion transport that may affect in uptake, distribution, loading and excretion of micronutrients within the plant parts [21] [22].

Along with salinity heavy metals also affect on early growth or regeneration of mangroves [23]-[28]. Older mangrove seedlings appeared to be more metal-tolerant than the younger seedlings due to their more efficient exclusion mechanism. Thus, the effects of metal contamination on young seedlings should be assessed when evaluating the risks posed by heavy metals in an ecosystem [29]. Most of the elements are stored in the soils and dead roots and may serve as a sensitive bio-indicator for metal pollution in these ecosystems [30].

In the Sundarban, the main sources of many heavy metals from industrial discharges as waste particle [31] [32]. On the other hand, the oil and gas mining activities also showed harmful for the mangrove habitats biodiversity and ecosystems. So, such affects may change the hydro edaphic condition of the forest by accelerates to change over the biochemistry of the wetland ecosystem [33] [34].

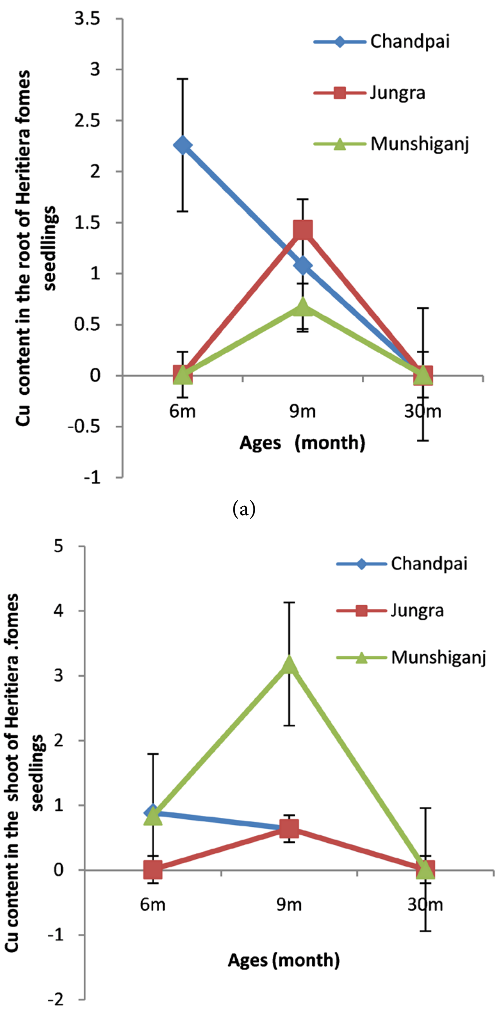
Therefore, to know the abiotic stresses due to accumulation of micronutrients or essential heavy metals, the present study aims to assess the distribution and toxic content of the such micronutrients or essential heavy metals like Cu Zn and Fe in the different parts of the major mangrove *viz. Heritiera fomes*.

2. Materials and Methods

Major mangrove tree species of the Sundarban forest *viz. Heritiera fomes* Buch, was selected for the present investigation. The Field study was conducted in three different saline zones which are—Chandpai, Jungra and Munshiganj as Oligohaline (4 - 8 $dS^{-1}·m$), Mesohaline (8 - 15 $dS^{-1}·m$) and Polihaline (>15 $dS^{-1}·m$) zones respectively were selected as an experiment site. The Chandpai and Jungra zones are in Chandpai range and Munshiganj zone in Satkhira range of the Sundarban forest. Nine sample plots (9 × 10 m^2) have been laid out in these three different saline zones for sample collection. After seed dropping naturally regenerated *Heritiera fomes* seedlings (6, 9 and 30 months ages) were randomly collected as plant sample from these plots. After washed they excised as root and shoot and then oven dried at 80˚C until constant weight. The plant samples were ground and processed according to the standard procedure [35] for determining the total copper (Cu), Zinc (Zn) andiron (Fe) by Atomic Absorption Spectrometer (Model: Varian AA240 Atomic Absorption Spectrometer Australia).

3. Result and Discussion

Micronutrient or essential heavy metals like, Cu, Zn and Fe content were analyzed in the *Heritiera fomes* seedlings. Among them Cu and Zn content showed remarkably higher than Fe. Whereas comparatively higher Cu was found in the root (2.26 mg/g) but higher Zn was found in the root and the shoot (0.788 mg/g and 0.804 mg/g) of 6 months age *Heritiera fomes* seedlings grown at the Chandpai (oligohaline) zone (**Figure 1**, **Figure 2**). However at the 9 months comparatively higher content of Cu was found in the root of the seedlings (1.43 mg/g) grown at the Jungra (mesohaline) zone but in the shoot of the 9 months age *H. fomes* showed comparatively higher Cu content (3.18 mg/g) at the Munshiganj (polyhaline) zone. These elements are toxic to organisms at high concentration. But they do not inhabit germination but cause strong barrier of seedling growth at relatively low concentration [36]. On the other hand, harmless level of these elements were also found in China mangrove forest [37]. These metals act as micronutrients and need small amount to contribute to plants metabolic necessities.



(b)

Figure 1. Cu content in the Root (a) and the Shoot (b) of *Heritiera fomes* seedlings.

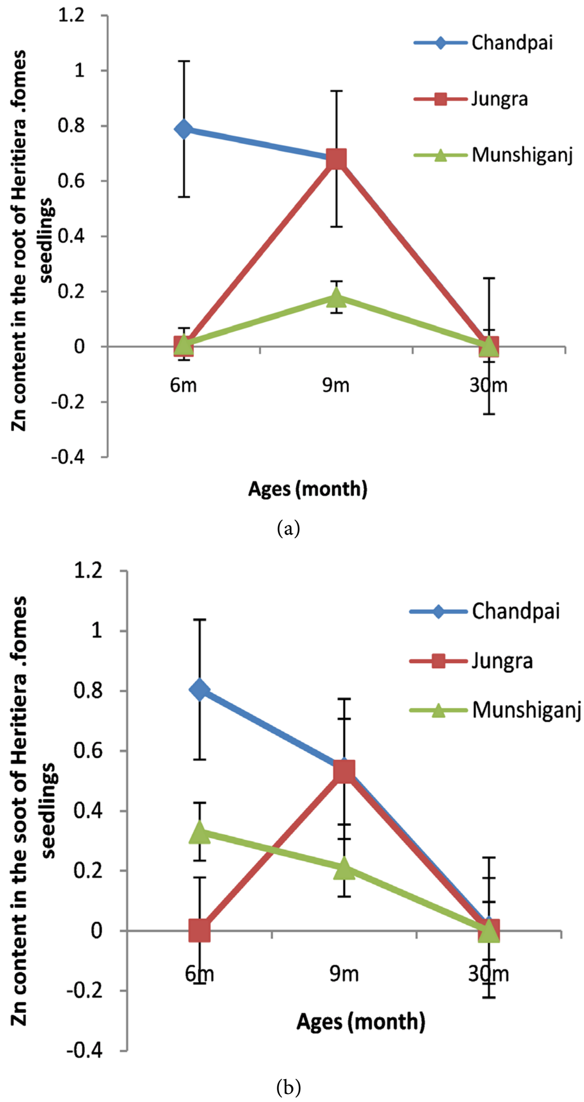


Figure 2. Zn content in the Root (a) and the Shoot (b) of *Heritiera fomes* seedlings.

Their lack may damage the whole enzymatic system but excess can alter cell membrane permeability and inhabit enzyme activity by interfere the different metabolic processes. However, Cu and Zn were found comparatively lower at the age of 30 months (0.01 mg/g - 0.002 mg/g and 0.01 mg/g - 0.00004 mg/g) (Figure 1, Figure 2). On the other hand, relatively higher Fe content were found in 30 months root and shoot of *H. fomes* seedlings grown at Chandpai saline (less saline) zone (0.02 mg/g) but lower in 6 months old seedlings (Figure 3). Higher content of Cu and Zn were also noticed by many researchers in the early seedling stages [38]. Present observation also noticed that *H. fomes* also showed relatively lower content of micronutrients (Cu and Zn) in the older age *viz.* 30 months due to their more efficient ion exclusion or avoiding mechanism. It was also reported that at the older ages' mangrove seedlings appeared to be more metal-tolerant than the younger ages [30].

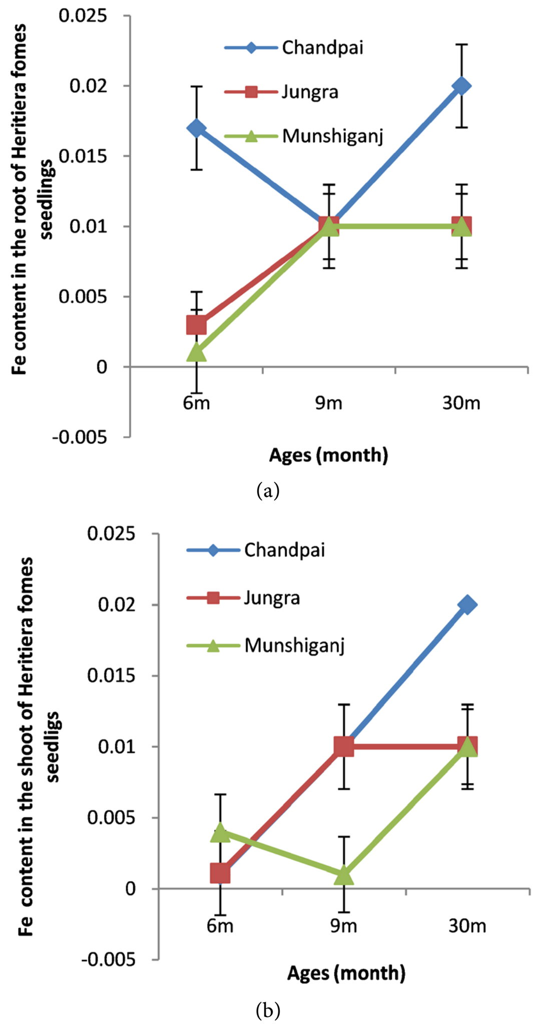


Figure 3. Fe content in the Root and the shoot of *Heritiera fomes* seedlings.

4. Conclusion

The *Heritiera fomes* species in early seedling stage are affected with high content of micronutrient or heavy metal and response differently by tolerance of metals in different plant parts and ages. At the older age seedlings appeared to be more metal-tolerant than the younger age seedlings. Thus, the effects of metal contamination on young seedlings should be assessed when evaluating the risks posed by heavy metals in an ecosystem.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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