FEASIBILITY ANALYSIS OF *HERITIERA FOMES* (SUNDRI) PLANTATION TO MINIMIZE TOP DYING EFFECTS IN THE SUNDARBANS OF BANGLADESH

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ABSTRACT

A lot of *Heritiera fomes* (Sundri) trees have been dying due to a disorder known as top dying disorder, caused by different environmental, physicochemical and pathological factors. A study was initiated to increased yield by capturing higher genetic gain and availability of pests and diseases free sundri for sustainable production. All seeds were collected from selected 30 healthy sundri trees and seedlings were planted in three salinity zones of Sundarbans from 2010-2017. Plantations at fresh water zone always showed the high growth in height (m) and high survival rate (%). Mean height and survival rate (%) for Sundri plantations were 1.82m and 58.95% respectively. The mean height for less, moderate and strong saline zones were 2.31m, 1.63m and 0.73m where mean survival rate (%) were 81.84%, 38.75% and 49.51% respectively. Creating more Sundri stand from top dying free mother tree will compensation the loss of top dying and thus minimize the top dying effect in Sundarbans.

Keywords: *Heritiera fomes (Sundri), nursery, Sundarbans, survival percentage, top dying.*

INTRODUCTION

Mangroves are important forest ecosystem among the tropical and sub-tropical forests types that dominate approximately 75% of the world's coastline between 25°N and 25°S latitude (Field, 1995). They are the most productive in terms of gross primary productivity (GPP). Mangroves have been heavily used traditionally for food, timber, fuel and medicine (Alongi, 2002). Over the past 50 years, approximately one-third of the world's mangrove forests have been lost (Alongi, 2002). Mangroves are a valuable ecological and economic resource, being important nursery grounds and breeding sites for birds, fish, crustaceans, shellfish, reptiles and mammals; a renewable source of wood; accumulation sites for sediment, contaminants, carbon and nutrients; and offer protection against coastal erosion, cyclones and tsunami (Paolini and Sánchez-Arias, 2008; Danielsen, *et al*., 2005; Kathiresan and Rajendran, 2005; Badola and Hussain, 2005; Alongi, 2002; Mazda *et al*., 1997; Holmgren, 1994). The people adjacent to Sundarbans collects fish, honey, golpata, fuel wood, hogla, prawn, hantal, crab,

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nall, grass, keora fruit, malia, goran stick, molasses and medicinal plants from the Sundarbans (Azad *et al*., 2020; Islam *et al*., 2020).

Sundarbans, the largest single tract of mangrove forest in the world, lie within the delta of the Ganges, Brahmaputra and Meghna rivers in the Bay of Bengal (Islam, 2006; Islam & Gnauck, 2008). This forest declared as 'Reserve Forest' during 1875-76, and was placed under the Forest Department (FD) for management. Since then, its area in Bangladesh has remained unchanged and at present, it extends over 600,000 hectares of which 175,724 hectares is water (Rahman, 1995). Therefore, the FD is the management and conservation custodian of both forest and aquatic resources. This forest is rich in both floral and faunal diversity compared to other mangroves of the world. Prain (1903), Seidensticker & Hai (1983) recorded 334 species of plants belonging to 245 genera and 75 families for the Sundarbans and adjoining areas. According to two reputable scientific studies, mangroves include approximately 16-24 families and 54-75 species (Tomlinson, 1986; Field, 1995) respectively whereas Karim (1994b) reported 123 plant species belonging to 22 families representing 30 genera in SMF in Bangladesh and Helal Siddiqui (2009) reported about 230 species including non-mangroves. *Heritirea fomes* is the dominant species of the Sundarbans, which alone constitute 64% of the forest area (Chaffey *et al*., 1985, Rahman, 1995). While, *H. fomes* - *Excoecaria agallocha*, *E. agallocha*- *H. fomes* and *Ceriops decandra* dominated forest types constitute 29.7%, 14.8% and 14.46% of the forest area, respectively (Siddiqui, 2001). *Heritiera fomes* (Sundri) is the keystone species as well as important timber resource of the Sundarbans in terms of abundance, distribution and commercial value. Previously this specie was commercially harvested for construction purpose.

Due to climatic change, edaphic factor, various natural and anthropogenic causes this are depleting gradually. At the same time various disease caused by different pests and insects are responsible to destroy this shelterbelt. Top dying of sundri (*Heritiera fomes*) is one of them. Rahman (1990) calculated over 45.2 million sundri trees have been affected by top dying where 25.02 million trees occupying 25446 ha had developed moderate top dying (less than 50% of the crown dead) and 20.18 million trees covering 19,848 ha were severely affected (more than 50% of the crown dead) based on the data provided by Chaffey *et al*. (1985). Rahman (1990) listed the following as the possible causes of top dying of sundri: increase in salinity due to reduction of the flow of fresh water; modification in the depth and duration of flooding; development of pathogenic gall canker on sundri branches; cryptic root damage due to repeated cyclones; epicormic branching following cyclone damage on the crown; increased siltation; loranthus infestation; insect damage; old age; and deficiency of micronutrient. Different scientists described about top dying in different ways and tried to find its solution. However, this study helps to optimize the problem of top dying as it was conducted through collecting of seedlings from top dying free mother trees.

Monitoring or continuous investigation up to several years needed to find out the actual performance of Sundri. This study has been undertaken to observe the feasibility and growth performance (survival percentage and height) of artificial plantation to minimize the top dying effects and increase the number of Sundri in the Sundarbans of Bangladesh.

METHODOLOGY

To conduct this study, vigorous seeds of sundri was collected from healthy, forkless and disease-free mother trees or plus trees of the Sundarbans. Proper nursing and management were provided of those seeds and propagules and seedlings of Sundri were raised in polybags in the nursery bed. After getting seedling from nursery bed experimental plantations of sundri were raised in 3 salinity zones (Less salinity zone, moderate salinity zone and strong salinity zone) at 1m x 1m spacing. The three saline zones are low (<2 dsm^{-1}), moderate (2–4 dsm^{-1}), and high (>4 dsm^{-1}), symbolizing them as oligohaline (OHZ), mesohaline (MHZ) and polyhaline (PHZ) zone, respectively (Chaffey *et al*., 1985; Siddiqui, 2001). Bogi situated in low saline zone where Malleh Chattar, Takimari, Hular Char's located in moderate saline zone and Munshigong placed in strong saline zone. Survival and growth data from the experimental plantations at six months interval was collected and compiled. All the data were analyzed by Microsoft Excel-2019 package.

Fig. 1. Seedlings in the nursery of sundry

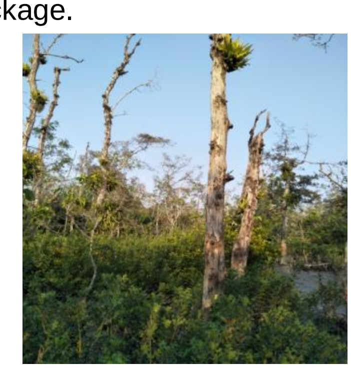

Fig. 2. Top dying affected sundri in the Sundarbans

Fig. 3. Sundri Stand

RESULTS AND DISCUSSION

It is not clear when top dying of sundri *(Heritiera fomes)* was first seen in the Sundarbans but reports suggested that it could have been present at the beginning of this century. However, there is no indication that the disease syndrome was either widespread or causing significant losses until the early 1970s. The problem had become serious enough several years later, in 1975. However, this study helps to optimize the problem of top dying as it was conducted through collecting of seedlings from top dying free mother trees. The study was carried out in several consecutive years and different locations of Sundarbans with the objectives of filling the vacant area within Sundarbans. It also aimed to create new plantations in newly formed charlands and embankment of rivers within Sundarbans.

It was observed that the survival percentage of *H. fomes* was always high in less saline zone (93%, 74%, 69%, 74%, 64% and 98%) for all the plantation year (Fig-4). The survival rate (%) were very poor (0.25%) at strong salinity zone in 2016, but showed high performance (98.77%) in 2017 (Fig-4). In addition, the height growth also high in less saline zone except moderate saline zone (1.62m) showed higher height growth than less saline zone (1.29m) in 2013 (Fig-4).

Fig. 4. Mean height and survival percentage of three saline zones

It was found that the mean height (m) was 1.82m for Sundri plantations with minimum 0.64m, maximum 6.07m and standard deviation 1.41 in three saline zones of the Sundarbans (Table-1). The minimum, maximum and mean height of less saline zone was 1.29m, 6.07m and 2.31m; moderate saline zone was 0.64m, 3.91m and 1.63m; strong saline zone was 0.70m, 0.75m and 0.73m with the standard deviation of 1.71, 1.16 and 0.04 respectively (Table-1). Rahman, (2019) reported that the mean height of *H. fomes* were 2.18m and 1.88m for six-year plantation (2011) which were higher than top dying free (1.44m), less top dying (0.95m), moderately top dying (0.99m) and less than severely affected area (3.44m).

Table 1. Minimum, maximum, mean height and SD of three salinity zones in the Sundarbans

Salinity Zone	Minimum Height (m)	Maximum Height (m)	Mean Height (m)	SD
Less Saline Zone	1.29	6.07	2.31	1.71
Moderate Saline Zone	0.64	3.91	1.63	1.16
Strong Saline Zone	0.70	0.75	0.73	0.04
Total	0.64	6.07	1.82	1.41

However, the mean survival rate (%) was 58.95% for Sundri plantations with minimum 0.25%, maximum 98.77% and standard deviation 36.74 in three saline zones of the Sundarbans (Table-2). The minimum, maximum and mean survival rate (%) of less saline zone was 64.2%, 98.77% and 81.84%; moderate saline zone was 5.53%, 95% and 38.75%; strong saline zone was 0.25%, 98.77% and 49.51% with the standard deviation of 14.78, 35.07 and 69.66 respectively (Table-2). Rahman (2019) reported that the survival percentage of *H. fomes* at top dying free, less top dying, moderately top dying and severely affected area were 51%, 35%, 37% and 87% respectively. Alam (2014) was also found the highest (86.67%) survival percentage of Keora in Chaurfari site, whereas, in Badarkhali it was 80%. He also reported that the seedlings survival percentage in all species in Chaurfari and Badarkhali sites revealed the declining rate with time where Gewa (6.67%) presented the lowest rate in Chaurfari plantation site (Alam, 2014). The survival of mangroves is generally poor and plantation often needs up to 3 years for better performance (Saenger & Siddiqi, 1993). The survival rate of an experimental plots at Barisal coastal area in 5-year-old *S. apetala* ranged 29-52% (Siddiqi, 1987). Saenger & Siddiqi (1993) also perceived for *A. officinalis* plantation after 5-years in the Chittagong coastal district ranged 30-60%. Other hand, most of the restoration efforts in the Philippines through *Rhizophora* sp. have failed due to lack of proper hydrological and ecological assessment (Sharma, 2017).

Table 2. Minimum, maximum, mean survival rate and SD of three saline zones in the Sundarbans

Salinity Zone	Minimum Survival rate (%)	Maximum Survival rate (%)	Mean Survival rate (%)	SD
Less Saline Zone	64.20	98.77	81.84	14.78
Moderate Saline Zone	5.93	95.00	38.75	35.07
Strong Saline Zone	0.25	98.77	49.51	69.66
Total	0.25	98.77	58.95	36.74

The Sundarbans offer outstanding prospects for developing ecotourism (Dey *et al*., 2020). The scenic beauty, river cruise, wildlife watching, and hiking activities in the Sundarbans attract many tourists each year. Unfortunately, the Sundarbans lost its biodiversity considerably (Siddiqui *et al*., 2021) like other forests of Bangladesh (Uddin *et al*., 2021). So, various plantation techniques applied for enhancing the diversity. Though artificial plantations reduced the diversity of natural forests (Rahman *et al*., 2020), but it essential for protecting newly form charlands within and adjacent to the Sundarbans from occupancy and also enhancing storing carbon (AMK Azad *et al*., 2021, Pitol *et al*., 2019). It also fills the blank areas of the Sundarbans and extends scenic beauty. It observed that *H. fomes* plantations showed the higher survival rate than other mangroves species. Creating more Sundri stand from top dying free mother tree will compensation the loss of top dying and thus minimize the top dying effect in Sundarbans. So, for creating plantation to fill the barren area within mangroves, plantation of *H. fomes* will be better choice than other mangroves.

LIMITATIONS

The growth of sundri stand is very slow and it takes more than 100 years to reach maximum yield. The old tree of Sundri is mainly affected by top dying, which needs more than 40-50 years. Besides, taking land for creating plantations took some years, so we planted some consecutive years immediately after approval. Longer time needed to get actual and precise result. So, further study needed not only for sundri but also others major mangroves species in the Sundarbans.

CONCLUSION

Sundri (*Heritiera fomes*), the major and economically important tree species in the Sundarbans has been affected severely causing death of the trees from top to downwards. It occurs throughout the whole Sundarbans of Bangladesh more or less. This study reveals that the artificial plantation of sundri is feasible and showed high growth and survival rate in many areas of the forest. It encourages creating more plantations in Sundarbans and newly formed char lands adjacent to the Sundarbans for mitigating the top dying effects of sundri. Responsible authorities will try to create more plantations of mangroves species and enhance the sustainable management of the largest single tract mangroves forest in the world.

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