

Survival and Growth Performance of Four Native Palm Species in the Central Coastal Belt of Bangladesh

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Abstract

Plantation Trial Unit Division of Bangladesh Forest Research Institute (BFRI) carried out a research in the central coastal belt (Noakhali area) of Bangladesh with *Areca catechu* L., *Cocos nucifera* L., *Phoenix sylvestris* Roxb., and *Borassus flabellifer* L. from 2019 to 2021 in order to assess the growth performance of these four native palm species. Seedlings of these species, except *C. nucifera*, were raised in polybags, and 10–12-months-old seedlings were planted in the field in June of every year. The study was laid out in a Randomized Complete Block Design (RCBD) with 3 replications and the spacing was 1.82 m for *A. catechu* and 5.48 m for other three species. *A. catechu* had the highest survivability (96.67 and 70.33%) after 0.5 and 2.5 years of plantation, and *C. nucifera* had the highest (86.67%) survivability after 1.5 years of plantation. On the other hand, *B. flabellifer* had the lowest survivability (77.78%) after 0.5 years of plantation and *P. sylvestris* had the lowest (58.87 and 40.07%) after 1.5 years and 2.5 years. After 0.5, 1.5, and 2.5 years of plantation, *C. nucifera* had the highest (1.13, 1.67, and 6.62 m) and *B. flabellifer* had the lowest (0.51, 0.75, and 1.08 m) height. After 0.5, 1.5, and 2.5 years of plantation, the highest numbers of new fonds were found for *C. nucifera* (3.51 nos.), *A. catechu* (3.69 nos.), and *P. sylvestris* (4.67 nos.), respectively. But the lowest numbers (2.04, 3.34, and 3.33 nos.) of new fonds were found for *B. flabellifer*. This result will be helpful for raising large-scale plantations with these four palm species in the Noakhali coastal belt areas of Bangladesh.

সারসংক্ষেপ

বাংলাদেশ বন গবেষণা ইনস্টিটিউট এর অধীন প্লান্টেশন ট্রায়েল ইউনিট বিভাগ, বাংলাদেশের মধ্য উপকূলীয় অঞ্চলে (নোয়াখালী এলাকায়) ২০১৯ থেকে ২০২১ সাল পর্যন্ত *Areca catechu* (সুপারি), *Cocos nucifera* (নারিকেল), *Phoenix sylvestris* (খেজুর) এবং *Borassus flabellifer* (তাল) এই ৪টি দেশীয় পাম প্রজাতির প্রাথমিক পারফরম্যান্স নির্ধারণের জন্য একটি গবেষণা চালায়। *Cocos nucifera* ছাড়া অন্য প্রজাতির চারাগুলো পলিবাগে তোলা হয় এবং ১০-১২ মাস বয়সী চারা প্রতি বছরের জুন মাসে রোপণ করা হয়। গবেষণাটি ৩টি প্রতিলিপিসহ র্যান্ডমাইজড কমপ্লিট ব্লক ডিজাইনে (আরসিবিডি) করা হয় যেখানে *A. catechu* এর জন্য রোপনের ব্যবধান ছিল ১.৮২ মিটার এবং অন্যান্য ৩টি প্রজাতির জন্য ৫.৪৮ মিটার। *Areca catechu* রোপনের ০.৫ এবং ২.৫ বছর পরে সর্বোচ্চ (৯৬.৬৭ এবং ৭০.৩৩%) বেঁচে ছিল, কিন্তু *C. nucifera* রোপনের ১.৫ বছর পর সর্বোচ্চ (৮৬.৬৭%) বেঁচে ছিল। অন্যদিকে, *B. flabellifer* রোপনের ০.৫ বছর পর সর্বনিম্ন (৭৭.৭৮%) এবং *P. sylvestris* রোপনের ১.৫ এবং ২.৫ বছর পর সর্বনিম্ন (৫৮.৮৭ এবং ৪০.০৭%) বেঁচে ছিল। রোপনের ০.৫, ১.৫ এবং ২.৫ বছর পর *C. nucifera* এর উচ্চতা সর্বোচ্চ (১.১৩, ১.৬৭, এবং ৬.৬২ মি.) এবং *B. flabellifer* উচ্চতা সর্বনিম্ন (০.৫১, ০.৭৫, এবং ১.০৮ মি.) ছিল। রোপনের ০.৫, ১.৫ এবং ২.৫ বছর পর যথাক্রমে *C. nucifera* (৩.৫১টি), *A. catechu* (৩.৬৯টি), এবং *P. sylvestris* এ সর্বাধিক সংখ্যক (৪.৬৭টি) নতুন পাতা পাওয়া গেছে, তবে প্রতিক্ষেত্রেই *B. flabellifer* এ সর্বনিম্ন (২.০৪, ৩.৩৪, এবং ৩.৩৩টি) সংখ্যক নতুন পাতা পাওয়া গেছে। গবেষণার এই ফলাফল, বাংলাদেশের নোয়াখালী উপকূলীয় অঞ্চলে, এই চারটি পাম প্রজাতি দিয়ে বৃহৎ পরিসরে বনায়নের ক্ষেত্রে বিশেষ ভূমিকা পালন করবে।

Keywords: *Areca catechu*, *Borassus flabellifer*, Central coastal belt, *Cocos nucifera*, Growth performance, *Phoenix sylvestris*.

Introduction

Palms (family Palmae or, more recently, Arecaceae) commonly dominate the rural landscape in tropical countries (Mogea *et al.* 1991). Palms are one of the most important horticultural crops in many countries (Rahman *et al.* 2021; Rana and Islam 2010; James 1980; Kamal 1969) and provide most of the necessities of life for humans in the tropics for centuries (Nath *et al.* 2002). There are around 230 genera and 2,700 palm species, most of which are found in tropical and subtropical climates (Pasha 2006) being an essential and fundamental feature of tropical forests (Johnson 1995). Bangladesh being in the tropics, has a diverse range of palm trees, ranging from hilly topography to plain areas to muddy mangrove forests (Blatter 1978; Hussain 2001). At least 20 kinds of native palm trees occur in Bangladesh, while at least five foreign species are planted as avenue or garden plants (Pasha 2006). The most common palm tree species found in Bangladesh are Palmyra palm (*Borassus flabellifer*), Coconut (*Cocos nucifera*), date palm (*Phoenix sylvestris*), and betel nut (*Areca catechu*) (Rana and Islam 2010). Palm cultivation can provide a considerable financial return (Dowson 1982). The fruit, beverage, leaf, fiber, and stem of the palm tree are highly prized as food, thatching material, lumber, fuelwood, weaving mat, windbreak, raw material for oil production, canoe making etc. (Zaid 1999; Chan and Elevitch 2006; Mitchell and Ahmad 2006; Calzada *et al.* 2007; Rahman *et al.* 2011; Al-Adhroey 2011).

Borassus flabellifer (Palmyra palm) is considered one of the principal sugar-yielding palm among the 3000 multifunctional palms of the tropics and subtropics (Johnson 1983; Mogea *et al.* 1991). In the southern part of the

Bangladesh, it is widely planted for juice production (Nath *et al.* 2002) and it has medicinal benefits in all of its sections (Blatter 1978; CISRO 1985; Morton 1988). Another prominent economic palm in Bangladesh is *C. nucifera* (coconut), which is one of the country's most important homestead plantation crops (Pasha 2006; Rahman 2005, Dissanayake 1977). It is an important fruit tree in the globe, supplying sustenance for millions of people, particularly in tropical and subtropical countries, and it is often referred to as the "tree of life" because of its various uses (Chan and Elevitch 2006). *Areca catechu*, locally known as supari (Rashid *et al.* 2015), originated in the Philippines, is now widely grown throughout Bangladesh (Nandi *et al.*, 2019). This plant, which is primarily grown for the production of nuts or seeds and is an important component of betel pepper, has important medicinal properties (Nath and Karmakar 2001; Staples and Bevacqua 2006). *Phoenix sylvestris* is one of the most common popular palms ever found in Bangladesh and a well-known source of sugar (Blatter 1978; Hussain 2007) and its juice has been used to make traditional sweeteners (Ahmed, 2007). It provides food, ornament, material for shelter, fiber and fuel in a hard environment where relatively few other plants can grow (Zaid 1999), and frequently utilized in brick kilns (Sait *et al.* 2012; El May *et al.* 2012). Around 72.4 million people in Bangladesh live in rural areas and rely on agriculture and tree-based economic activities for their survival (BBS 2012), and the palm-based manufacturing system is one of the most essential ways to improve the economic, social, and environmental standards in Bangladesh's rural areas (Nandi *et al.* 2019). Palm tree species are one of the most important plantation trees in Bangladesh's Southeastern region for their fruits and sap collection (Pasha 2006; Nandi *et al.* 2019), and many rural farmers in this region rely on palm husbandry

for their seasonal livelihoods (Rana and Islam 2010). Because of the systematic cultivation of palm for better yield, it has received little attention in Bangladesh (Rana and Islam 2010; Rahman *et al.* 2011); Policymakers should pay close attention to assessing the potentials of palm (Nandi *et al.* 2019). A study was carried out in the western coastal areas of Bangladesh with these four native palm species and found promising. But no systematic study has been carried out with these four native palm species in the central coastal belt areas (Noakhali areas). Therefore, a research was carried out with four palm species (*B. flabellifer*, *C. nucifera*, *P. sylvestris*, and *A. catechu*) to assess their survival and growth performance in the central coastal belt of Bangladesh. This result will be helpful to improve the cultivation of palm, enrich palm biodiversity, and standardize the plantation techniques for large-scale plantations with these native palm species in Noakhali areas of Bangladesh.

Materials and Methods

Study area

The research was conducted at the Subarnachar upazila of Noakhali district of Bangladesh. Subarnachar upazila is situated between latitudes 22°23' and 22°45' north and longitudes 90°54' and 91°20' east (Miah *et al.* 2015; Prosun *et al.* 2018). It has a tropical climate with heavy rainfall for the majority of the year and a short dry season (Barua *et al.* 2019). The highest average annual temperature is 34.3°C and the lowest at 14.4°C, and the average annual rainfall is 3302 mm (BBS 2013). Soil pH ranges from 6.7 to 8.0, with soil salinity ranging from 6.6 to 13.9 dS/m during the rainy and dry seasons (SRDI 2010). With only 8 mm of precipitation, January is the coldest and driest month of the year (Hussain 2008).

Raising experimental plantation

In this research, four native palms, namely *C. nucifera* (coconut), *B. flabellifer* (palmyra palm), *P. sylvestris* (date palm) and *A. catechu* (betel nut) were used. The seeds collected from phenotypically superior trees and seedlings of these species, except *C. nucifera*, were raised in polybags. For raising *C. nucifera* seedlings, mature *C. nucifera* is directly put up in the seedbeds. Seedlings of all species are kept in the nursery for about 10–12 months. *B. flabellifer* seedlings were raised by the detached germ tube method. Ten to twelve-months old seedlings were planted in the field in a Randomized Complete Block Design (RCBD) with three replications. The plantation was carried out in the raised land and the embankment of the study area. The spacing was 5.48 m from seedling to seedling for *B. flabellifer*, *C. nucifera*, and *P. sylvestris* and 1.82 m for *A. catechu*. The experimental plantation for research was carried out during the months of June for 3 subsequent years of 2019, 2020 and 2021.

Data collection

Data was collected in December, 2021 after 0.5, 1.5, and 2.5 years of plantation planted in the years of 2021, 2020 and 2019 respectively.

Statistical analysis

The Excel spreadsheet and the R-Studio (version 3.3.0) were used to compute and analyze the data.

Results

Comparison of survivability

Survival performance of four species was found to decrease with the age of the plantation. The mean survivability of *A. catechu*, *C. nucifera*, *P. sylvestris*, and *B. flabellifer* was 96.67, 93.00, 78.53, and 77.78% respectively, after 0.5 years of planting in the plantation year of 2021 (Fig.1 & Table 1).

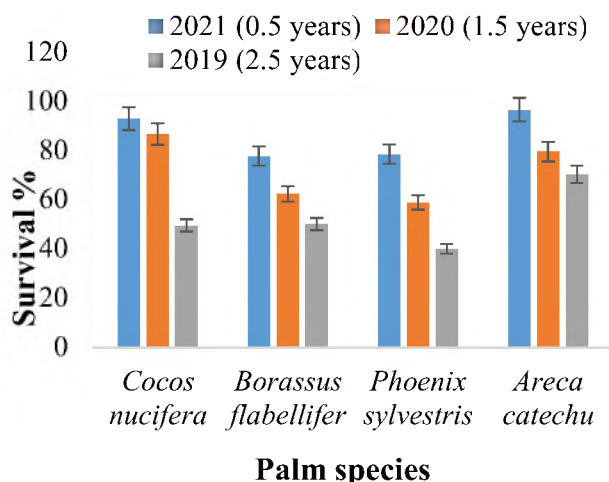


Figure 1. Survivability of four native palm species after 0.5, 1.5, and 2.5 years of plantation.

On the other hand, the mean survivability of *C. nucifera*, *A. catechu*, *B. flabellifer* and *P. sylvestris* was 86.67, 79.60, 62.40 and 58.87% respectively after 1.5 years of planting in the plantation year of 2020. The mean survivability of *A. catechu*, *B. flabellifer*, *C. nucifera*, and *P. sylvestris* was 70.33, 50.16, 49.59 and 40.07% respectively after 2.5 years of planting in the plantation year of 2019 (Fig. 1 & Table 1).

Comparison of height growth

The mean height of *C. nucifera*, *A. catechu*, *P. sylvestris* and *B. flabellifer* was 1.13, 0.61, 0.60 and 0.51m respectively after 0.5 years of planting (Fig. 2 & Table 2). On the other hand, the mean height of *C. nucifera*, *A. catechu*, *P. sylvestris* and *B. flabellifer* was 1.67, 1.40, 0.82 and 0.75m respectively after 1.5 years of planting. The mean height of *C. nucifera*, *A. catechu*, *P. sylvestris* and *B. flabellifer* was 6.62, 6.02, 1.19 and 1.08m, respectively after 2.5 years of planting (Fig. 2 & Table 2).

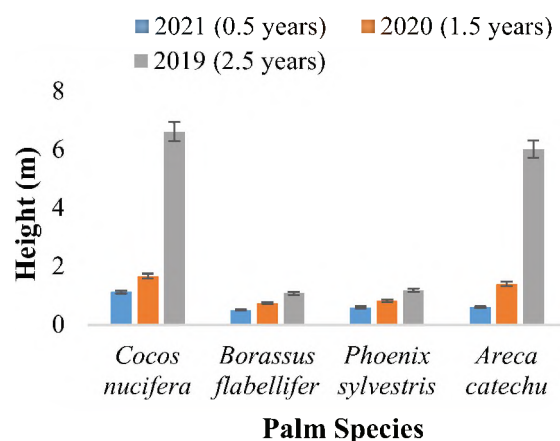


Figure 2. Height of four native palm species after 0.5, 1.5, and 2.5 years of plantation.

Table 1. Comparison of the survivability of four native palm species after 0.5, 1.5, and 2.5 years of planting in the central coastal belt of Bangladesh.

Plantation year	Age (Years)	Vernacular name	Scientific name	Survivability (%)
2021	0.5	Betel-nut	<i>A. catechu</i>	96.67 ± 0.45 ^a
		Coconut	<i>C. nucifera</i>	93.00 ± 3.60 ^a
		Date palm	<i>P. sylvestris</i>	78.53 ± 3.42 ^b
		Palmyra palm	<i>B. flabellifer</i>	77.78 ± 2.22 ^b
2020	1.5	Betel-nut	<i>A. catechu</i>	79.60 ± 3.20 ^a
		Coconut	<i>C. nucifera</i>	86.67 ± 1.66 ^a
		Date palm	<i>P. sylvestris</i>	58.87 ± 4.17 ^b
		Palmyra palm	<i>B. flabellifer</i>	62.40 ± 3.82 ^b
2019	2.5	Betel-nut	<i>A. catechu</i>	70.33 ± 2.90 ^a
		Coconut	<i>C. nucifera</i>	49.59 ± 3.60 ^b
		Date palm	<i>P. sylvestris</i>	40.07 ± 2.54 ^b
		Palmyra palm	<i>B. flabellifer</i>	50.16 ± 3.79 ^b

Note: Treatment values followed by different letters (like a, b, etc.) significantly differ at the 5% significance level.

Table 2. Comparison of the height of four native palm species after 0.5, 1.5, and 2.5 years of planting in the central coastal belt of Bangladesh.

Plantation year	Age (Years)	Vernacular name	Scientific name	Height (m)
2021	0.5	Betel-nut	<i>A. catechu</i>	0.61 ± 0.05^b
		Coconut	<i>C. nucifera</i>	1.13 ± 0.06^a
		Date palm	<i>P. sylvestris</i>	0.60 ± 0.03^b
		Palmyra palm	<i>B. flabellifer</i>	0.51 ± 0.02^b
2020	1.5	Betel-nut	<i>A. catechu</i>	1.40 ± 0.11^a
		Coconut	<i>C. nucifera</i>	1.67 ± 0.13^a
		Date palm	<i>P. sylvestris</i>	0.82 ± 0.10^b
		Palmyra palm	<i>B. flabellifer</i>	0.75 ± 0.04^b
2019	2.5	Betel-nut	<i>A. catechu</i>	6.02 ± 0.08^b
		Coconut	<i>C. nucifera</i>	6.62 ± 0.17^a
		Date palm	<i>P. sylvestris</i>	1.19 ± 0.07^c
		Palmyra palm	<i>B. flabellifer</i>	1.08 ± 0.05^c

Note: Treatment values followed by different letters significantly differ at the 5% significance level.

Comparison of new fonds production

The mean number of new fonds of *C. nucifera*, *A. catechu*, *P. sylvestris* and *B. flabellifer* was about 3.51, 3.42, 2.08, and 2.04 nos., respectively, after 0.5 years of planting (Fig. 3 & Table 3). On the other hand, the mean number of new fonds of *A. catechu*, *P. sylvestris*, *C. nucifera*, and *B. flabellifer* was about 3.69, 3.67, 3.60, and 3.34 nos. respectively after 2.5 years of planting. The mean number of new fonds of *P. sylvestris*, *A. catechu*, *C. nucifera* and *B. flabellifer* was about 4.67, 4.45, 3.67 and 3.33 nos. respectively after 2.5 years of planting (Fig. 3 & Table 3).

Mean annual increment of height

The mean annual height increment of *C. nucifera*, *A. catechu*, *P. sylvestris*, and *B.*

flabellifer was 2.65, 2.41, 0.48, and 0.43 m, respectively, after 2.5 years of planting (Table 4).

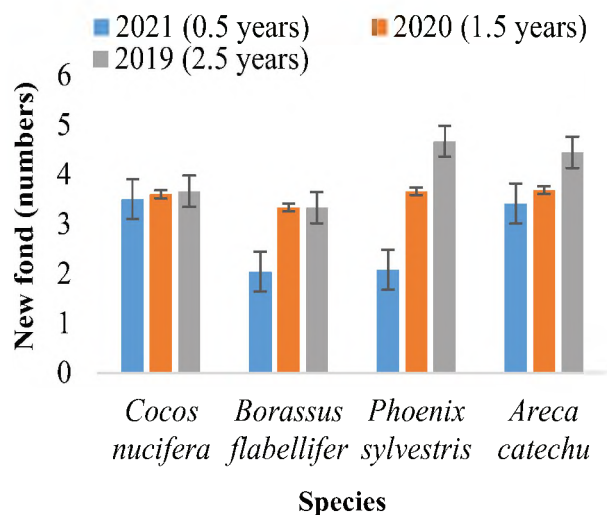


Figure 3. Number of new fonds of four native palm species after 0.5, 1.5, and 2.5 years of plantation

Table 3. Comparison of the new fonds of four native palm species after 0.5, 1.5, and 2.5 years of planting in the central coastal belt of Bangladesh.

Plantation year	Age (Years)	Vernacular name	Scientific name	New fond (nos.)
2021	0.5	Betel-nut	<i>A. catechu</i>	3.42 ± 0.15 ^a
		Coconut	<i>C. nucifera</i>	3.51 ± 0.36 ^a
		Date palm	<i>P. sylvestris</i>	2.08 ± 0.34 ^b
		Palmyra palm	<i>B. flabellifer</i>	2.04 ± 0.18 ^b
2020	1.5	Betel-nut	<i>A. catechu</i>	3.69 ± 0.66 ^a
		Coconut	<i>C. nucifera</i>	3.60 ± 0.22 ^a
		Date palm	<i>P. sylvestris</i>	3.67 ± 0.33 ^a
		Palmyra palm	<i>B. flabellifer</i>	3.34 ± 0.37 ^a
2019	2.5	Betel-nut	<i>A. catechu</i>	4.45 ± 0.27 ^a
		Coconut	<i>C. nucifera</i>	3.67 ± 0.33 ^{ab}
		Date palm	<i>P. sylvestris</i>	4.67 ± 0.33 ^a
		Palmyra palm	<i>B. flabellifer</i>	3.33 ± 0.30 ^b

Note: Treatment values followed by different letters (like a, b, etc.) significantly differ at the 5% significance level.

Table 4. Mean Annual Increment (MAI) of height of four native palm species after 2.5 years of plantation in the central coastal belt of Bangladesh.

Name of species	Age	Height (m)	MAI of height (m)
<i>A. catechu</i>	2.5	6.02 ± 0.08	2.41 ± 0.03
<i>C. nucifera</i>	2.5	6.62 ± 0.17	2.65 ± 0.07
<i>P. sylvestris</i>	2.5	1.19 ± 0.07	0.48 ± 0.03
<i>B. flabellifer</i>	2.5	1.08 ± 0.05	0.43 ± 0.01

Discussion

A significant difference was found among *A. catechu*, *C. nucifera*, *P. sylvestris* and *B. flabellifer* for survivability after 0.5, 1.5, and 2.5 years of plantation. After 0.5 years of planting, *A. catechu* had the highest (96.67%) and *B. flabellifer* had the lowest survivability (77.78%). However, after 1.5 years of planting, *C. nucifera* had the highest (86.67%) survivability, while *P. sylvestris* had the lowest

(58.87%). Finally, after 2.5 years of planting, the maximum survivability (70.33%) was found for *A. catechu* and the lowest (40.07%) for *P. sylvestris*. In consideration of survivability after 2.5 years *A. catechu* showed the most promising species than others. Survivability of these four native palm species was found promising after 0.5 years of plantation but gradually reduced after 1.5 and 2.5 years of plantation due to disturbances mainly by humans and cattle. Islam *et al.* (2014) found the survivability of *P. sylvestris*, *A. catechu*, *C. nucifera*, and *B. flabellifer* was 82%, 60%, 81%, and 65%, respectively, after 12 years of plantation in the western coastal belt of Bangladesh. A significant difference was also found among the four native palm species for height growth after 0.5, 1.5 and 2.5 years of plantation. For 0.5, 1.5 and 2.5 years of plantation, *C. nucifera* had the highest height (1.13, 1.67 and 6.62m) and *B. flabellifer* had the lowest height (0.51, 0.75 and 1.08m) in this study. Islam *et al.* (2014) found the height of *P. sylvestris*, *A. catechu*, *C. nucifera*, and *B. flabellifer* was 7.74m, 10.07m, 10.98m and

8.38m respectively after 12 years of plantation in the western coastal belt of Bangladesh. Generally, *C. nucifera* trees are found to grow 10 to 30 meters, *B. flabellifer* up to 30 meters, *P. sylvestris* 10 to 14 meters, and *A. catechu* 10 to 30 meters tall. Besides height, *P. sylvestris* was found to grow up to 50cm in diameter and *A. catechu* up to 15cm in diameter (Siddiqui *et al.* 2007). Moreover, a significant difference was found among the four palm species for the production of new fonds after 0.5, 1.5 and 2.5 years of plantation. The highest numbers of new fonds were found for *C. nucifera* 3.51 nos., *A. catechu* 3.69 nos., and *P. sylvestris* 4.67 nos., respectively, among the four species, after 0.5, 1.5 and 2.5 years of plantation. But in all cases (0.5, 1.5 and 2.5 years), the lowest number (2.04, 3.34, and 3.33 nos.) of new fonds was found for *B. flabellifer*. After 2.5 years of planting, the highest MAI was found for *A. catechu* (2.41m) and the lowest for *B. flabellifer* (0.43m). During the first 40 years of growth, *C. nucifera* grows at a moderate rate of about 30–50cm (12–20 inch) per year (Chan and Elevitch 2006), while *A. catechu* grows at a rate of 0.5m/year (20 inch/year) (Staples and Bevacqua 2006). The growth and yield of the palms are negatively affected by periods with mean daily temperatures below 21°C (70°F) (Chan and Elevitch 2006). Palm growth is also depending on the soil's ability to drain well during the rainy season and be rich in organic matters (Staples and Bevacqua 2006).

Conclusion

A significant difference found among *A. catechu*, *C. nucifera*, *P. sylvestris*, and *B. flabellifer* for survivability, height, and number of new fonds after 0.5, 1.5, and 2.5 years of plantation. The survivability of these four native species is promising after 0.5 years of plantation but gradually reduces after 1.5 and 2.5 years of plantation due to disturbances mainly by humans and cattle. In consideration

of survivability, the height growth, number of new fonds, and MAI, all the four native palm species were found promising. These palms are economically and ecologically important species in Bangladesh and serve as a strong shelterbelt against cyclonic storms. This result will be helpful for raising large-scale plantations with these four palm species in the Noakhali coastal belt areas of Bangladesh. This study should continue for a few years, and future research could be conducted by covering broad geographical ranges and highlighting the soil variables.

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