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Seed Germination in *Barringtonia acutangula*: A Floodplain Tree From North East India

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ABSTRACT

Flooding is a natural and periodic disturbance and the floodplain species possess numerous adaptation strategies to cope with the periods of waterlogging. *Barringtonia acutangula,* a tree that grows on the bank of the river is uniquely adapted to the aquatic conditions. The species has been managed by floodplain people of the North East India for their livelihood security through fish capture and trade over millennia. It is important to understand the seed germination behaviour of the species for better management of the *Barringtonia* trees. We describe seed germination in *Barringtonia acutangula* in relation to different seed mass category and pre-sowing treatments, under nursery and laboratory conditions. Depending on the variation in seed mass, seeds were classified into three weight classes namely: heavy (≥3g), intermediate (2 -3g) and light (1-2g). Seeds from different weight classes showed significant difference in the periodicity of seedling emergence (χ^2 = 9.83, p < .01). Heavy seeds exhibited better germination characteristics viz. high shoot length (F= 13.63, p <0.01), high root length (F = 2.97, p < 0.05), high dry weight per plant (F = 4.96, p < 0.05) except the number of leaves per plant (F= 1.15, p <0.05) over other seed categories. Seed weight exhibited positive correlation with seedling growth characteristics (R^2 = 0.84- 0.97). Pre-sowing treatments affected seed germination (F= 19.27 p <0.01) and seedling emergence time (F= 28 p<0.01). Study reveals that heavy seeds are important for better management of floodplain *Barringtonia* forest.

Key Words: Flooding; Seed Germination; Seed Mass; Seedling Growth

INTRODUCTION

Floodplains comprise a distinctive feature of the world geography. These are highly productive systems and important for social, ecological and economic values (Tockner 2008). Flood pulses extend the river onto the floodplain and directly affect nutrient availability and aquatic organisms (Valett 2005) and water velocity influence the plant community distribution by directly influencing the seed dispersal (Carollo et al. 2002). Many floodplain tree species disperse their seeds in flooding season (Parolin et al. 2003) and continuous submersion changes the seed viability and germination (Walls et al. 2005). To avoid anoxia generated by submersion many seeds from floodplain forest species have evolved tolerance to prolonged periods underwater, employing different strategies (Parolin et al. 2003). The determination of seed germination patterns and seedling establishment depend on seed responses to flooding duration (Walls et al. 2005).Seed size has important evolutionary and ecological significance (Moles and Westoby 2006) and the relationships between seed mass and seedling growth and performance have received significant consideration (Singh and Saxena 2009). Variation in seed mass may have distinct consequences for seed germination and seedling survival (Du and Huang 2008, Silveira et al. 2012). Due to larger seed reserves, seedlings from heavier seeds are able to withstand longer periods of drought stress and high temperatures than the small seeds (Du and Huang 2008) implying the significance of seed mass on seed germination. Moreover, the importance of pre-sowing treatments in promoting seed germination has also been emphasized (Karaguzel et al. 2002, Kozlowski 2004, Mölken et al. 2005).

Barringtonia acutangula (L.) Gaertn.(Family Lacythidaceae) locally known as "*Hijol"* is naturally growing tree that grows on the bank of the fresh water rivers, the edges of freshwater swamps and lagoons and on seasonally flooded lowland plains (Nath et al. 2015). The species grows well under seasonal submergence condition and is dominant tree species of Chatla floodplain, North East India (Nath et al. 2010). In the Chatla floodplain the species grows naturally and germination through seeds is the only mode of reproduction. The tree exhibit diversity in seed sizes and therefore may influence its germination behaviour. Once the tree develops local inhabitants protects and manages such trees. The species is intricately related with the socio-economy of the floodplain people and have been managed in pure stands over millennia (Nath et al. 2015). As *B. acutangula* has long been managed by the local inhabitants of the floodplain for their subsistence and commercial needs, it is important to explore seed germination behaviour of the species for long term floodplain forest management. Therefore, the present study aims to study the effect of seed mass on seed germination behaviour and seedling growth characteristics of *Barringtonia acutangula* from North East India. The hypotheses tested were the following: (i) heavy seeds can germinate faster than the light seeds, and (ii) pre-sowing treatments can accelerate the early seed germination.

The Studied Plant

B. acutangula is an evergreen tree (5-8m high) with rough fissured dark grey bark. Leaves short petioled cuneate elliptic, racemes elongate pendulous, fruit quadrangular oblong equally narrowed towards and subtruncate at each end (Hooker 1876). Throughout its range *B. acutangula* has been used in a variety of ways by local peoples (Nath et al. 2015). The species exhibit short duration deciduousness and leaf less period varied from 7-21 days (Nath et al. 2016). The fruiting phase of the species is extended over monsoon period (June – September) with peak during July-August (Nath et al. 2016). Individual seed weight varies from 1.15-4.06 g. Seeds are one-seeded berry and ovoid in shape. The species provides different types of subsistence and commercial goods including fuel wood, building materials, fodder etc. The branches/sprouts are used in the management of fishery. The cut branch measures diameter > 10 cm and the length >150 cm (Tree diameter >20 cm). The practice of the traditional cutting maintains the supply of branches, required for fish farming purpose (Nath et al. 2010). Dried leaves are collected by women and used as fuel for cooking purposes.

STUDY AREA

Present study was carried out in Chatla floodplain ($90^0 45^/$ North and $24^0 45^/$ East) in Cachar district of Barak Valley, Assam. Chatla is the catchment of river Ghagra, the tributary of river Barak. The topography of the area is low lying with numerous small hillocks in between that are inhabited by the villagers. The geographical area of Chatla is ~10 km^2. The major ethnic group in the Chatla is the 'Kaivartas', a fisher community. In both rainy and winter season, fisher community used to capture and trade fishes. The rainy season extends from May and continues up to October and winter extends from November to March. Mean annual temperature and annual rainfall (2012-2014) ranges from 18 to 30°C and 1800 to 2500 mm respectively. The floodplain is mainly dominated by the tree, *Barringtonia acutangula* (Nath et al. 2010).

METHODS

Seed Germination in Nursery Condition

Seed germination was studied using mature seeds freshly fallen to the ground or on water. Seed maturity was identified by the seed colour (Ochuodho 2005). Seeds were brought to the laboratory, measured individually and classified into three classes according to its mass viz. heavy (≥3g), intermediate (2 -3g) and light (1-2g). Seed weight was taken by using the electronic balance. Seeds were stored in sealed plastic bags at room temperature (22 ± 8ºC) and sown within a week. To check the viability, seeds from each class were directly immersed in tap water and cut with a sharp knife through the seeds and considered as viable if the endosperm is fleshy, moist and white in colour (Gribko and Jones 1995).

From each seed weight category, 60 seeds were sown separately in 20 × 17 cm sized polythene bags filled with field soil (Upadhaya et al. 2007). For each seedling one polythene bag was used. Experiment was started in September 2014. Watering was done once in three days to maintain soil moisture. Germination defined as shoot emergence was checked daily (Parolin et al. 2003). Five seedlings were selected randomly from each category to study the shoot length, root length, number of leaves and dry biomass. Randomly selected seedlings were uprooted from the nursery bag, brought it to the laboratory and washed through tap water. Following washing, root and shoot length were measured with the help of measuring scale, different plant parts were separated and fresh weight was noted. For obtaining dry biomass data, plant parts were oven dried at 75ºC to a constant weight. This process was repeated at weekly interval and continued up to 12 weeks.

Seed Germination with Pre-sowing Treatments

The experiment was set up in September 2014 in the laboratory condition at room temperature (22 ± 8°C). Experiment was designed with the following treatments :(i) seeds having seed coat, (ii) seeds soaked overnight in water, and (iii) without seed coat. Seeds from each weight class were placed in petri-dishes containing cotton and filter paper (Pandey and Tamta 2013). Five seeds from each weight class and each treatment were used for the present study. Seeds were considered as germinated when the radical was protruded about 1 mm.

Moisture Content Determination

For moisture content study, freshly fallen 90 seeds were collected covering all the seed weight classes. The fresh weight of seeds from each weight classes were taken with the help of electronic balance and oven dried at 105°C to a constant weight to calculate moisture content percentage (El Balla et al. 2011).

Statistical Analysis

The normality characteristics of the measured data were tested using the Kolmogorov-Smirnov test for the acceptance of null hypothesis using the software SPSS 17.0. The χ^2 (Chi- square) test (Zar 1999) and one way analysis of variance (ANOVA) was performed using the software MS Excel 2010.

RESULTS

A total of 300 seeds were weighed and seed mass varied from 1.05 to 6.89g per seed. Frequency distribution of seeds size is represented in Figure 1. Seeds from different weight classes showed significant effect on seedling emergence time ($\chi^2 = 9.83$ $p < 0.01$). Effect of seed weight on seed germination and mean germination time is presented in Figure 2. Seedling growth was measured in terms of shoot length, root length, number of leaves and dry weight. The normality characteristics of the measured data were tested using Kolmogorov-Smirnov test ($p = 0.200$) which indicates the acceptance of null hypothesis i.e. the data followed the normal distribution. Seed weight showed the significant effect on shoot length ($F= 13.63$ $p < 0.01$), root length ($F = 2.973$ $p < 0.05$), dry weight per plant ($F = 4.96$ $p < 0.05$) except number of leaves per plant ($F = 1.15$ $p > 0.05$) (Table 1). Heavy seeds emerged rapidly and completed germination faster than the intermediate and light weight seeds (Figure 3). Seed weight showed the positive correlation with seedling growth characteristics ($R^2= 0.84 - 0.97$). The relationship between initial seed weight and other seedling growth characteristics based on regression analysis indicated seed weight has strong impact on seedling vigour (Table 2).

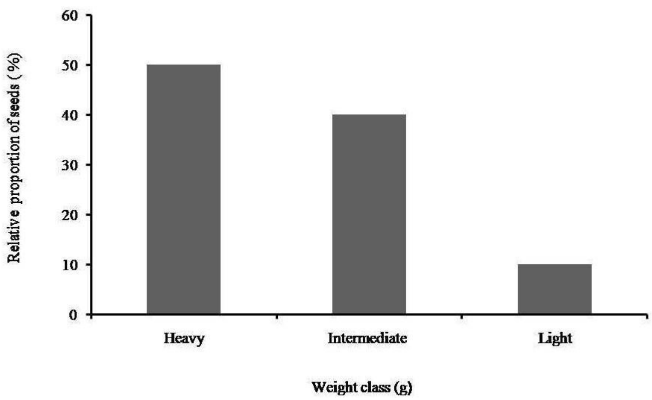

Figure 1. Relative proportion of seeds according to seed weight class

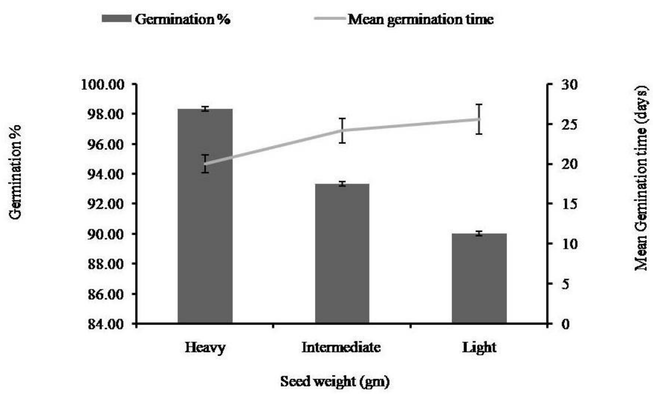

Figure 2. Effect of seed weight on seed germination (%) and seed germination time of *Barringtonia acutangula*

Table 1. Seedling shoot length (cm), root length (cm), number of leaves/plant and dry weight/plant (g) of *B. acutangula* seeds in heavy, intermediate and light weight classes after 90 days of germination.

Seed weight	Shoot length	Root length	No. of leaves/ plant	Dry weight/plant
Heavy	28.34 ±.81[a]	26.23 ± .90[a]	7.63 ± .35[a]	.64 ± .06[a]
Intermediate	23.89 ± .84[b]	23.78 ± .83[b]	7.38 ± .30[a]	.55 ± .05[b]
Light	22.69 ± .85[c]	21.69 ± .88[c]	7.02 ± .31[a]	.41 ± .05[c]

Different letter is showing significance level at $p < 0.01$ and $P < 0.05$

Table 2. Regression equation for the relationship between initial seed weight and different studied variables such as shoot length(cm), root length (cm), number of leaves/plant and dry weight/plant (g) of *B. acutangula.*

Variables	Regression equation	R^2
Shoot length	Y= 2.6806x+ 17.944	0.979
Root length	Y= 1.2363 x + 20.114	0.840
No. of leaves per plant	Y =.3019 x + 6.5751	0.960
Dry weight per plant	Y = 0.1054x + .2582	0.933

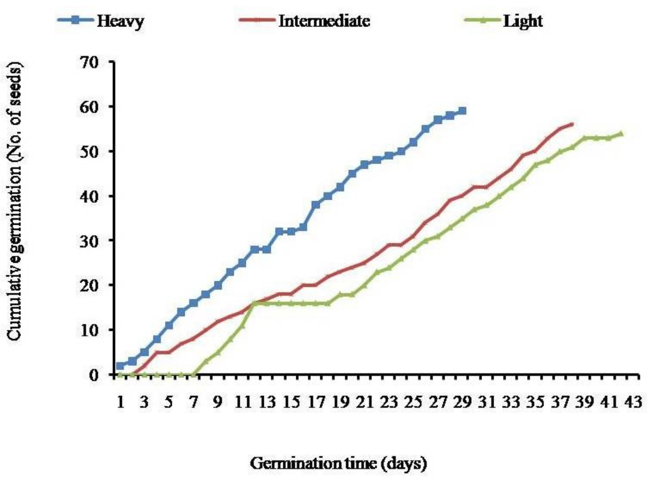

Figure 3. Germination curves of heavy, intermediate and light weight seeds of *Barringtonia acutangula*

Heavy seeds had higher moisture content than the intermediate and light weight seeds (Figure 4). Soaking seeds with and without seed coat significantly minimized the emergence time ($F= 28, p<0.01$) and maximized the seed germination ($F= 19.27, p<0.01$) over the non-soaked seeds having seed coat (Table 3).

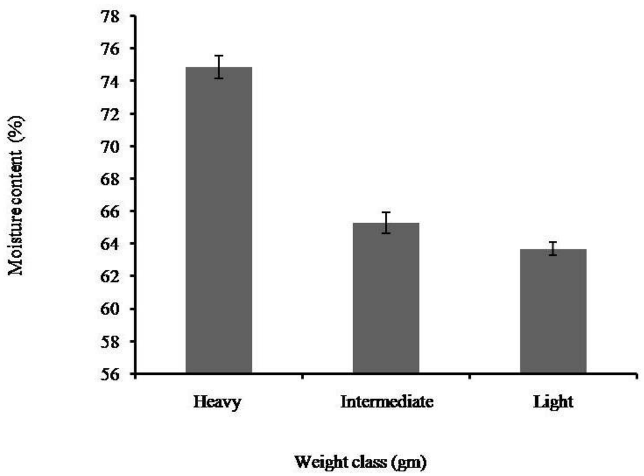

Figure 4. Seed moisture content (%) of *Barringtonia acutangula* according to the seed weight

DISCUSSION

Seeds of *Barringtonia acutangula* are orthodox (McDonald 2004) in nature and seed weight variation influences the seed and seedling germination. A wide variation was found in seed weight of *Barringtonia acutangula*. The variation in seed size and weight within a sample may be due to genetic or environmental differences (Schmidt 2000). Moreover, seed mass is the main factor that determines germination characteristics (Parciak 2002). A close relationship between seed weight and production of good quality planting materials has been observed for many tropical tree species (Sivasubramaniam and Selvarani 2012). The present study showed seed weight affected the seedling emergence and other associated germination parameters. Heavy seeds germinated faster than the other seed category and characterized with higher germination rate. Therefore, heavy seeds possess sufficient stored energy

Table 3. Germination behavior of seeds with pre sowing treatment (seeds sown = 25).

Seed weight class	Number of seeds germinated			Emergence time (days)		
	Seeds with seed coat; not soaked	Seeds soaked overnight	Seeds without seed coat	Seeds with seed coat; not soaked	Seeds soaked overnight	Seeds without seed coat
Heavy	12±.31[a]	22 ± .16[b]	24 ± .17[c]	6 ± .31[a]	3.1 ± .10[b]	2.2 ± .95[c]
Intermediate	9 ± .43[a]	15 ± .18[b]	23 ± .18[c]	8 ± .43[a]	4.3 ± .11[b]	3.5 ± .97[c]
Light	7 ± 46[a]	11 ± .21[b]	20 ± .21[c]	9 ± .45[a]	5.2 ± .12[b]	4.5 ± .97[c]

Mean with the different superscript letter are significant at p < .01

to survive until they support themselves photo-synthetically (Du and Huang 2008). Moreover, large amount of reserves in heavy seeds improves germination and growth and decreases dispersal efficiency with the increase in seed weight (Mishra et al. 2014) and lesspredation risk (Khan and Uma Shankar 2001). However, contradictory results have been reported for many tropical tree species in which lighter seeds germinated earlier than the heavier and have been attributed to thick seed coat in the former (Upadhaya 2007). The seedling of heavier seeds showed the greater shoot and root length and high dry biomass. This might be because larger embryo with greater food reserve promotes higher seedling growth (Khan and Uma Shankar 2001; Khan et al. 2002). Similarly, greater plant growth and dry weight of seedlings from heavy seeds have been reported for *Bassia longifolia* (Suresh et al. 2003), *Mesua ferrea* (Arunachalam et al. 2003), *Acacia nilotica* and *Albizia lebbek* (Khera et al. 2004), *Colophospermum mopane* (Nagarajan and Mertia 2006). The positive correlation between seedling vigour and the initial seed weight suggests the seedling from heavier seeds is more competitive. Similar findings were reported (Khan et al. 2002).

Heavy seeds showed high moisture content than the other two seed categories. Standifer et al. (1989) suggested that seed moisture is an important factor in seed development with the critical level of moisture required for germination. Therefore, certain influential factors (moisture content) can also regulate in conjunction with seed mass. In the present study, seed soaking showed better germination and early emergence than that of non-soaking seeds. Seeds soaked overnight took less time for germination, could be, perhaps, overnight soaking allowed the seeds to imbibe water easily as a result of which the seed coats were softened, thus allowing enzymatic activities to take place results in early seed germination (Kozlowski 2004; Farooqet al. 2005). Similar results have been reported for other tropical tree species (Kozlowski 2004). On the other hand the light seeds are carried to longer distances by run-off water (personal observations) thus indicating that lighter seeds may help in dispersal of *Barringtonia* seeds. Similar observation was reported in *Artocarpus heterophyllus*(Khan 2004).The scarified seeds showed significantly higher germination percentage and less emergence time. Higher germination percentage is probably due to water and gases entering the embryo early through the cracks and causing a series of enzymatic breakdown resulted in the transformation of the embryo into a seedling early enough than other seed treatments (Karaguzel et al. 2004).Similar results have been reported with other plant species viz. *Lupinusvarius* (Karaguzelet al. 2002), *Prunus webbii* (Heidari et al. 2008) and *Aeluropus lagopoides* (Zaman et al. 2011). The delayed germination of the seed having seed coat probably due to the permeability of water or oxygen or both that prevents seed for germination (Gunaga et al. 2011). Therefore, pre sowing treatment promotes higher germination with less emergence time in *Barringtonia acutangula*.

CONCLUSIONS

Data presented proved both the hypotheses that heavy seeds germinate faster and the pre-sowing treatments accelerate the germination time. The analytical data from the present study also supports the following conclusions: (i) seed mass strongly influence the seed germination rate in *B. acutangula*, (ii) maintenance of heavy seeds is most important for the regulation of viable population *B. acutangula,* (iii) sufficient moisture content of heavy seeds helps in producing better seedling, (iv) seeds without seed coat promote early germination and, (v) further studies are needed to understand ecological significance of different seed sizes in sustaining *Barringtonia* forest.

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