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RESEARCH ARTICLE

THE EFFECT OF SEED WEIGHT AND SIZE ON GERMINATION AND GROWTH OF *PARKIA TIMORIANA* (DC.) MERR. (SYN. *P. ROXBURGHII* G. DON.), A MULTIPURPOSE TREE AND A DELICIOUS VEGETABLE OF MANIPUR, INDIA

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ABSTRACT

Parkia timoriana (DC.) Merr. (Syn. *P. roxburghii* G. Don.), belongs to the family Mimosaceae, is a multipurpose tree and a delicious vegetable of Manipur. It shows wide variation in seed weight and seed size. The effect of seed weight and seed size on germination, seedling survival and growth were evaluated. Seeds were grouped into 3 classes each on weight (< 0.8 g, 0.8 - 1g and >1g classes) and size (diameter) (<12mm, 12-13mm and >13mm classes). The seedlings were allowed to grow and various parameters were collected for survival and growth studies. After a period of 6 months final growth parameters as well as above and below ground biomass were measured. It was found that seed germination, seedling survival rate, growth and biomass accumulation were better in seeds with weight >1g seeds among the seed weight classes; and in 12-13 mm seeds among the seed size (diameter) classes. Heavier seeds confer an advantage to their seedlings for survival and growth due to the presence of large reserve of nutritive substances. Better performance of medium size seeds probably constitutes an evolutionary trade-off between dispersal and establishment capabilities that is adaptive for most plants. Therefore, for large scale plantation of *P. timoriana,* heavier (>1g) and medium size (12-13 mm) seeds should be selected for better survival and growth.

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INTRODUCTION

Seed size and weight in tree seedling performance has received considerable attention (Tripathi and Khan, 1990; Bonfil, 1998). Seed size is an important life history trait influencing regeneration success (Paz *et al*. 1999; Turnbull *et al*. 1999). The wide differences in seed mass among species have been regarded as an important aspect of reproductive strategy (Grubb, 1996). Seed mass plays an important role in the establishment of the juvenile phase of the life cycle, principally under conditions where resources are scare (Grubb and Coomes, 1997; Grubb and Burslem, 1998; Meyer and Carlson, 2001). Large and heavy seeds have better seedling survival and growth than small seeds (Bonfil, 1998; Vera, 1997). Foster (1986) argued that large seed reserves might be used for the construction of large amounts of photosynthetic tissue in order to maintain a positive net energy balance, or might also allow quick seedling growth for reaching higher light intensity strata.

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Large seeded species have an advantage in competitive environments and when seedlings experience defoliation (Armstrong and Westoby, 1993) or moisture stress (Baker, 1972). Heavy seeds not only have a competitive advantage of early and greater germination, but also have greater seedling survival and dry mass than those from small seeds may linked with the large reserve of nutritive substances (Tripathi and Khan, 1990; Kang *et al*., 1992; Paulina *et al*., 1998; Arunachalam *et al*., 2003; Upadhaya *et* al., 2007). Germination, survival and growth of seedlings are influenced largely by the food reserve in seeds, which increases with seed weight (Tripathi and Khan, 1990; Ke and Werger, 1999; Khan and Uma Shankar, 2001; Arunachalam *et al*., 2003).

Tripathi and Khan (1990) argued that a larger reserve in seeds may allow for the better pre-photosynthetic growth of seedlings and this in turn may contribute to the better growth and survival of seedlings that emerge from heavy seeds. However, there are other reports that are quite opposite to their finding. Marshell (1986) argued that small seeds may germinate at higher percentages than large seeds. In few multi-purpose tree species medium size seeds performed better than small or large seeds (Dar *et al*., 2002; Khera *et al*., 2004). Germination may be independent of seed size and seed weight (Perez-Garcia *et al*., 1995). *P. timoriana* (DC.) Merr. (Syn. *P. roxburghii* G. Don.), Mimosaceae is a multipurpose tree and shows wide variation in seed weight and seed size. The seeds of *Parkia* spp. have a low percentage of germination in the field (Etejere *et al.,* 1982) and the dormancy of these seeds has been attributed to the presence of inhibitor as well as the impermeable seed coat (Fasidi *et al.,* 2000). In recent years considerable increase in the cost of pods was recorded in local markets due to decline in the yield and mass dying of tree beans in Manipur. During the peak season, price fetches up to Rs 100/- per 3-4 pods.

Moreover, it is suitable species for reclamation of abandoned Jhum land and also for Agro-forestry system of cultivation as it fast growing leguminous species (enrich soil through nitrogen fixation) bearing fruits (source of income) and presence of large network of fine root system (help in soil conservation). It is a multipurpose tree having potential commercial and ecological significance in the region (Kanjilal *et al*., 1982). The plant increase soil nutrient availability particularly N and P contents of soil (Das, *et al*., 2009). Biomass of the plant possess narrow C/N ratio and decomposes rapidly leading to nitrogen mineralization in the soil (Uyovbisere and Elemo, 2002). The plant has quite significance value in Manipur. It is the first plant to be planted around the house by any family when a new house is made or a new home garden is created. It is also planted along the boundaries of fish ponds which serve as secondary source of income in pisciculture. In Manipur it is considered as the most costly vegetable. Both flowers and pods are eaten as vegetable. The Manipuri takes this vegetable as raw in an indigenous salad called *Singju* or as a boiled and smashed preparation called *Eromba* (Yumnam and Tripathi, 2012). Nutritionally, the species is found to contain high amount of crude protein, essential amino acids, fatty acids such as oleic and linoleic acids (Mohan and Janardhan, 1993). The essential amino acid pattern of the kernel was comparable to the FAO/WHO/UNU (1985) amino acid requirement for preschoolers (Longvah and Deosthale, 1998). Mizos, Garos, Kacharis, Nagas, Mikirs are also consuming the pods as vegetables.

The people in Manipur used pod as carminative, against piles and regulate liver functions (Bhuyan, 1996). The Dimasa Kacharis use the bark in the form of paste as plaster in eczema. In Malaya, Pods pounded in water are also used for washing the head and face. Bark and the leaves are employed in making lotion for skin diseases and ulcer (Bhuyan, 1996). Thioproline, a cyclic sulphur-containing amino acid which give seeds a particular pungent smell, (Suvachittanont *et al.,* 1996) is known to be anti-carcinogenic and inhibits the formation of squamous cell carcinomas in the fore-stomach of rats (Tahira *et al*., 1984 and 1988). The bark is reported to be suitable for tanning; it is used for dyeing nets in Philippines (Bhuyan, 1996). The oil extract of the plant possesses insecticidal properties (Salam *et al*., 1995) and the woods can be used as a source of paper pulp (CSIR, 1996). It is also a good source of firewood. In favourable season a full grown plant bears 10,000 -15,000 pods. A single plant can yield approx. Rs.8.000 /- to 10,000 /- per annum. The cost of the seeds per Kg. range from Rs. 100 /- to Rs.120 /- (Approx. 1000 seeds = I Kg.) (Bhuyan, 1996). In recent years considerable increase in the cost (Rs. 200/- to Rs. 300/- per Kg.) was recorded in local markets. Tree bean is conventionally propagated through seeds (Bhuyan, 1996), however, its seeds have a low percentage of germination in the field (Etejere *et al*., 1982). The objective of the present study was to determine if the differences in seed weight and seed diameter affect germination, seedling survival and growth. This information may be helpful for large-scale plantations of this species.

MATERIALS AND METHODS

Species study

P. timoriana (DC.) Merr. (Syn. *P. roxburghii* G. Don.), Mimosaceae is distributed from north-east India to Irian Jaya (Hopkins, 1994). The plant is native to Bangladesh, Brunie, East Timor, India, Indonesia, Myanmar, Peninsular Malaysia, Philippines and many of the South Asian countries (Bisby *et al*, 2008). The species occurs abundantly in all the valley and hill districts of Manipur, Mizoram and Barak valleys of Assam in North East India. It is a large tree upto 25 m high with spreading branches. Leaves upto 6 cm long, bipinnate. Flowers 1-1.5 cm long in long peduncled heads, calyx 5 cleft, corolla pale yellow , stamens 10, pods 25-50 x 3.5-4 cm , mostly green in colour and are found in a cluster of 20-40 pods from a single stalk. Seed about 15-30 nos. in each pod, oval shaped, and deep black in colour. Pods and dried seeds are showed in Figure 1 (a and b). Flowering and fruiting of the plant is in September to October and November to April respectively. The tree can thrive in different agro-climatic regions from colder hilly regions to the hotter plains (Salam and Singh, 1997). It grows well in different soil types particularly black clayed soils, loamy sandy soils as well as leached red hill soil. The life span of this tree may be 80-90 years or even more. It is known by the names Tree bean (English), Yongchak (Manipuri), Manipur-urohi (Assamese), Manipuri seem (Bengali), supota/kharial (Hindi), Zongto (Mizo) and Aoelgap (Garo).

Study site

The study was carried out in net house of the North Eastern Regional Institute of Science and Technology (NERIST) campus (27˚ 07' N lat, 93˚ 22' E long, 126 m a.s.l.) in Arunachal Pradesh, India. The region experiences tropical rain forest climatic condition. The winter (November-February) is cool (16˚ C) and dry (54% relative humidity) and the summer (March-October) is hot (36˚ C) and wet (80-98% relative humidity), with mean annual precipitation (1800 mm) distributed fairly evenly throughout the year.

Methodology

To study the effects of seed weight and size on seed germination, seedling survival and growth of *P. timoriana*, seeds were brought from Imphal valley, Manipur to laboratory at NERIST, Nirjuli, Arunachal Pradesh. Seed weight was measured using digital weighing machine and seed size (diameter) measured using digital caliper. Seeds were grouped into 3 classes each on weight (< 0.8 g, 0.8 - 1g and >1g classes) and size (diameter) (<12mm, 12-13mm and >13mm classes).

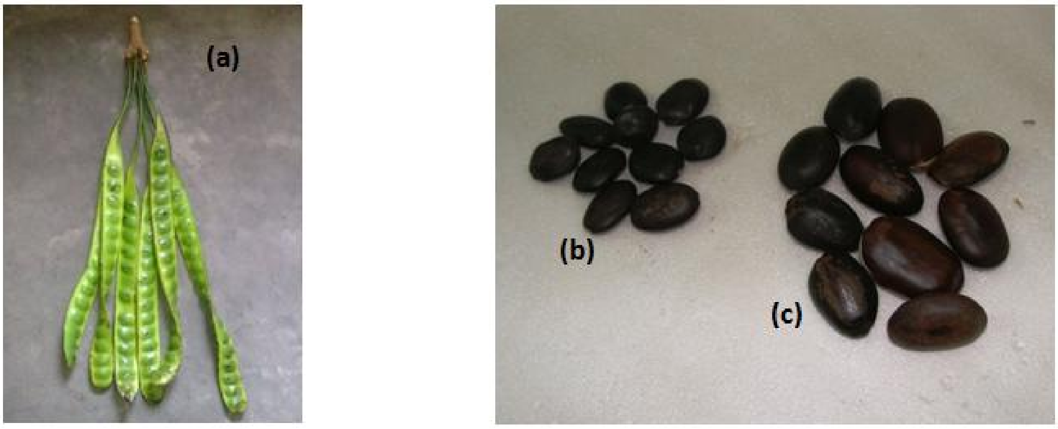

Fig. 1. *Parkia timoriana* (DC.) Merr. – (a) Pods and (b) Dried Seeds & (c) Seeds after soaking in water over night.

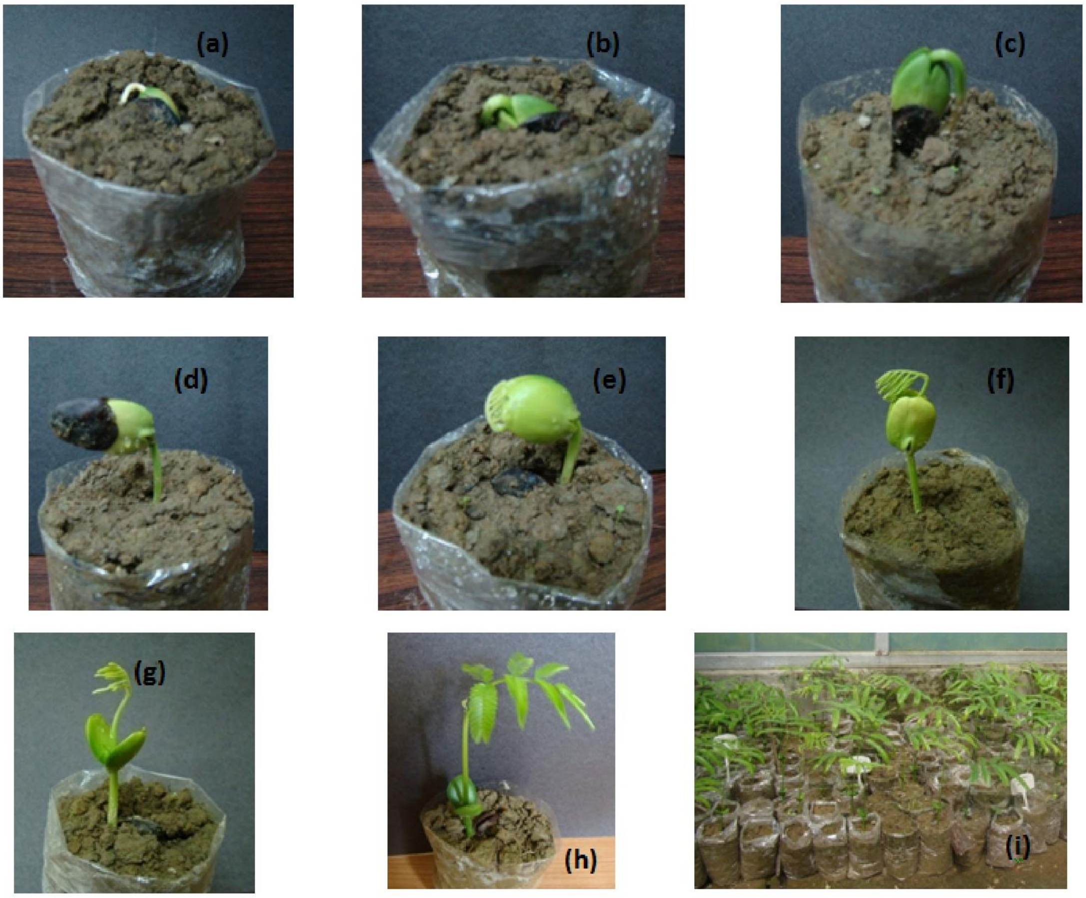

Fig. 2. Various stages of seed germination and growth of *Parkia timoriana* (DC.) Merr. (a) Radical emerged, (b) Radical curved toward soil and touched it, (c) & (d) Radical pulling up the plumule, (e) First leaves emerged, (f) First leaves appeared, (g) & (h) Stages of seedling & (i) Seedlings after 6 months from germination

The seeds were soaked in water for 24 hours (Fig. 1c) for easy removal of seed coat as the dormancy of these seeds has been attributed to the presence of inhibitor as well as the impermeable seed coat (Fasidi et. al., 2000). The seed coats were removed and seeds were sown separately in 12.5cm x 19cm polythene bags filled with garden soil on 19 September 2009, and watered every alternate day to moisten the soil. A seed with a protruding radical of about 2 mm was considered germinated.

The time required between sowing and emergence of radicle from the soil surface was considered as germination time. The time between germination and development of first pair of leaves was recorded as leaf emergence time. Seedling emergence was recorded until seedlings ceased to emerge. The seedlings were allowed to grow and various data were collected for survival and growth studies. Ungerminated seeds were discarded. Various stages of seed germination and seed growth are showed in Figure 2 (a-i).

Growths of the entire surviving seedlings were measured after 6 months viz. on 19 March, 2010. For the study seedling height, shoot collar diameter, leaf number and root length were measured of all the plants in each group except root length where only 5 plants representative were taken. Besides, to determine the biomass (dry), 5 plants representative of each group were pulled out carefully and washed. Individual plants were cut into above and below ground parts and put in oven at constant temperature of 105˚C for 24 hours and weight measured by digital weighing machine (Delmer) separately to obtain dry above and below ground biomass. All the data thus collected were than subjected to statistical analysis - one way Analysis of Variance (ANOVA) followed by *post hoc* pair wise multiple comparisons called as Fisher's Least Significant Difference (LSD) test using statistical analysis package SPSS 16.0.

RESULTS

Seed germination

Germination is epigeal, cotyledons are forced above the ground by elongation of the hypocotyls. Germination started by 3rd day and ceased by 17th day. Germination was highest in 12-13 mm seed class (64%) than other seed classes (54%) (Table 1). Mean germination time (days) of seeds grew to seedling was least in 12 -13 mm seed class (4±0.57 days), followed by >13 mm seed class (9±1.08 days) and highest in <12 mm seed class (10±1.15 days) in seed diameter classes. In seed weight classes, mean germination time was least in >1 g seed class (4±0.57), followed by <.8 g seed class (4.5± 0.64) and highest in .8 – 1 g seed class (5.5± 0.76) (Table 1).

Seedling survival and growth

81.25 % of germinated seeds grew to seedlings in 12-13 mm seed class, followed by <12 mm seed class (70.37%) and least in >13 mm seed class (66.66 %) in seed diameter class. In weight classes, 92.59 % of germinated seeds grew to seedlings in >1 g seed class, followed by .8 -1 g seed class (81.48 %) and least in <.8 g (74.07 %) (Table 1). 52% of total seed sown were grew to seedling in 12-13 mm seed class, followed by 38% and 36% in 12 mm and >13 mm seed classes respectively (Table 1).

Growth after 6 months from sowing

Various parameters such as seedling height (cm), collar diameter (mm), leaf no. per plant, root lenght and biomass accumulation both above and below ground was measure after 6 month from sowing to know the growth performance. Seedling height (36.5±3.56 cm), root length (8.9±0.94 cm), collar diameter (5.59±0.35 mm) and leaf no. per plant (5.6±0.24) were highest in 12-13 mm seed class in seed diameter classes, followed by seedling height (31.3±1.95 cm), root length (7.5±0.52 cm) and leaf no. per plant (5±0.44) in >13 mm class and collar diameter (5.3±0.39) in <12 mm.

Least seedling height (29.12±2.56 cm), root length (7.1±0.62 cm) and leaf no. per plant (3.8±0.48) in <12 mm seed class and collar diameter (4.52±0.23) in >13 mm seed class(Table 2). Seedling height (34.3±3.38 cm), root length (8.5±0.89 cm), collar diameter (5.40±0.31 mm) and leaf no. per plant (4.8±0.58) were highest in >1g seed class in seed weight classes, followed by .8-1 g seed class and <.8 g seed class (Table 2). In seed size (diameter) classes seedling height and root length were not significantly different, however, collar diameter and leaf number per plant were significantly different among the seed size (diameter) classes (Table 2).

Table 1. Seed germination and germination time

Seed classes	Seeds sown	Total seeds germinated (%)	Germinated seeds grew to seedling (%)	Mean germination time (days)	Total seed sown grew to seedling (%)
Seed size (diameter)					
<12mm	50	54	70.37	10±1.15	38
12-13mm	50	64	81.25	4±0.57	52
>13mm	50	54	66.66	9±1.08	36
Seed weight					
<.8g	50	54	74.07	4.5±0.64	40
.8-1g	50	54	81.48	5.5±0.76	44
>1g	50	54	92.59	4±0.57	50

Table 1. Seed germination and germination time

Seed classes	Seedling growth			
	Seedling height (cm)	Root length (cm)	Collar diameter (mm)	Leaf no. per plant
Seed size (diameter)				
<12mm	29.12±2.56*^{abc}	7.10±0.62 ^{abc}	5.30±0.39 ^{abc}	3.80±0.48^{ac}
12-13mm	36.50±3.56 ^{abc}	8.90±0.94 ^{abc}	5.59±0.35^{ab}	5.60±0.24^{bc}
>13mm	31.30±1.95 ^{abc}	7.50±0.52 ^{abc}	4.52±0.23^{ac}	5±00.44 ^{abc}
F value	1.87	1.73	2.71	5.04
Seed weight				
<.8g	22.50±1.93^{ab}	5.60±0.36 ^{ab}	4.18±0.25^{ab}	3.80±0.48 ^{abc}
.8-1g	30.80±3.36 ^{abc}	7.60±0.84 ^{abc}	4.50±0.39 ^{abc}	4.80±0.66 ^{abc}
>1g	34.30±3.38^{bc}	8.50±0.89^{bc}	5.40±0.31^{bc}	4.80±0.58 ^{abc}
F value	3.75	4.01	4.05	0.98

*means followed with the same letters are not significantly different ($p<0.05$)

In case of seed weight classes seedling height, root length and collar diameter were significantly different except leaf number per plant (Table 2).

In seed size (diameter) classes, biomass accumulation i.e. dry weight per plant (g) both above and below ground were highest (4.06±0.41 and 1.39±0.13 respectively) in 12 -13 mm seed class, followed by >13 mm class (2.9±0.18) and least in <12 mm (2.74±0.29) in above ground biomass while in below ground biomass it is followed by <12 mm class (1.23±0.16) and least in >13 mm class (1.04±0.16). In seed weight classes, biomass accumulation i.e. dry weight per plant (g) both above and below ground were highest (2.72±0.19 and 1.44±0.06 respectively) in >1g seed class, followed by .8-1g class (2.67±0.27) and least in <.8g (1.64±0.11) in above ground while in below ground biomass it is followed by <.8g (1.28±0.13) and least in .8-1g (1.27±0.20) (Table 3). In both seed size (diameter) and seed weight classes above ground dry weight per plant were significantly different, however, below ground dry weight per plant were not significantly different (Table 3).

Table 3. Dry weight per plant (g) after 6 months from germination

	Dry weight per plant (g)	
	Above ground	Below ground
Seed size (diameter)		
<12mm	2.74±0.29*[ac]	1.23±0.16 [abc]
12-13mm	4.06±0.41	1.39±0.13 [abc]
>13mm	2.90±0.18 [ac]	1.04±0.16 [abc]
F value	5.26	1.20
Seed weight		
<.8g	1.64±0.11	1.28±0.13 [abc]
.8-1g	2.67±0.27[bc]	1.27±0.20 [abc]
>1g	2.72±0.19 [bc]	1.44±0.06 [abc]
F value	9.01	0.38

*means followed with the same letters are not significantly different (p<0.05)

DISCUSSION

Seed weight and size (diameter) varies within a species necessitating segregation of seeds that would or would not germinate and establish seedling. A plausible explanation for variation in seed weight is the ability of the species to establish in a mosaic of micro sites with different physical and biotic conditions, thus boarding its regeneration niche (McGinley *et al*., 1987). Variation in seed size is also known to help seeds escape predation (Uma Shaanker *et al*. 1988). Among the seed weight classes of *P. timoriana*, heavier seeds (>1g seed class) also performed better than lighter seeds (<.8g and .8-1 g seed classes). This could be due to the reason that heavier seeds confer an advantage to their seedlings for survival and growth due to the presence of large reserve of nutritive substances (Tripathi and Khan, 1990; Vera, 1997; Bonfil, 1998; Ke and Werger, 1999; Khan and Uma Shankar, 2001).

Among the seed size (diameter) classes of *P. timoriana*, medium size seeds (12-13 mm seed class) germinate and accumulate more biomass than small or larger seeds (<12 mm and >13 mm seed classes respectively). This finding is also found in some multi-purpose trees (Dar *et al*., 2002; Khera *et al*., 2004). Better performance of medium size seeds probably constitutes an evolutionary trade-off between dispersal and establishment capabilities that is adaptive for most plants (Howe and Richter, 1982). From the study it was found that in terms of germination as well as in seedling growth and biomass (dry weight) accumulation, medium size seeds (12-13 mm seed class) and heavier seeds (>1g seed class) performed better than other seed classes. Therefore, it may be concluded that for large scale plantation, medium size and heavier seeds should be selected for better survival and growth.

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