Turk J Bot
31 (2007) 31-36

Research Article

The Effect of Seed Mass on Germination, Seedling Survival and Growth in *Prunus jenkinsii* Hook.f. & Thoms.

Krishna UPADHAYA[1], Harendra Nath PANDEY[2,*], Pynsakhiat S. LAW[2]

[1]Department of Basic and Social Sciences School of Technology, North-Eastern Hill University, Shillong 793 022 - INDIA

[2]Department of Botany, School of Life Sciences North-Eastern Hill University, Shillong 793 022 - INDIA

Received: 02.05.2006
Accepted: 10.10.2006

Abstract: The effect of seed mass on germination, seedling survival and growth was investigated in *Prunus jenkinsii* Hook.f. & Thoms. (Rosaceae), an evergreen tree species. Seed mass varied from a minimum of 0.5 g to a maximum of 2.72 g. Seed mass had a significant effect on the percentage of seeds that germinated: 28%, 41% and 42%, respectively, of light- (1.5 g), intermediate- (> 1.5 to 2 g) and heavy-weight (> 2 g) seeds germinated. After 1 year of germination, the seedlings that arose from heavy-, intermediate- and light-weight seeds showed 80%, 63% and 42% survival, respectively. Seedling vigour, expressed in terms of shoot and root length, number of leaves, leaf area and dry matter yield, was significantly affected by seed mass. Seedlings that emerged from heavy seeds showed better growth and produced heavier seedlings as compared to intermediate- and light-weight seed categories.

Key Words: Seed mass, germination, seedling survival, seedling vigour

Introduction

The role of seed size and weight in tree seedling performance has received considerable attention (Foster & Janson, 1985; Tripathi & Khan, 1990; Bonfil, 1998). 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 & Coomes, 1997; Grubb & Burslem, 1998; Meyer & Carlson, 2001). Foster (1986) listed several potential advantages of large seeds of tropical trees from moist forests and 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. Differences in seed mass have also been related to the ecological conditions in which plants establish, with species from open habitats having lower seed mass than species from more closed habitats (Foster & Janson, 1985). Large-seeded species have an advantage in competitive environments (Gross, 1984) and when seedlings experience defoliation (Armstrong & Westoby, 1993) or moisture stress (Baker, 1972).

Germination, survival and growth of seedlings are influenced largely by the food reserve in seeds, which increases with seed weight (Tripathi & Khan, 1990; Khan & Uma Shankar, 2001). Conflicting reports exist on the interspecific variation in seed weight and germination behaviour. For instance, large seeds may germinate at higher percentages than small seeds (Tripathi & Khan, 1990; Bhuyan et al., 2000; Khan & Uma Shanker, 2001), and small seeds may germinate at higher percentages than large seeds (Marshell, 1986), or germination may be independent of seed size (Gross & Kromer, 1986; Perez-Garcia et al., 1995). Within a species, heavier seeds may take less time for germination than lighter seeds (Barik et al., 1996), lighter seeds may germinate earlier than the heavier seeds (Murali, 1997; Khan et al., 1999) and germination time may be independent of seed weight (Perez-Garcia et al., 1995).

Prunus jenkinsii, an important indigenous tree species of subtropical broad-leaved forests of north-east India

* Email: pandeyhn@yahoo.com

shows wide variation in seed weight. The objectives of the present study were to determine if the differences in seed weight affect germinability and if seedlings derived from heavier seeds are more competitive and have high survival and vigour. This information is desired for developing protocols for large-scale plantations of this species.

Materials and Methods

Study species

Prunus jenkinsii Hook.f. & Thoms. (Rosaceae) is an evergreen, late successional species. It naturally forms the canopy as well as the subcanopy of moist subtropical forests up to 1600 m asl (Balakrishnan, 1981). It attains a height of 25 m or more. The distribution of the species is restricted to north-eastern India (Haridasan & Rao, 1985; Kanjilal et al., 1997). It reproduces both by shoot coppice and through seeds. The seeds germinate mostly in moist shady places. The ripe fruits are edible; therefore, it is grown in homestead gardens. The fruits are dispersed by rodents and birds, which eat the pulp of the fruits.

Seed source

Mature fruits of *P. jenkinsii* were collected in April 2002 from subtropical broad-leaved hill forest at Raliang (lat 25°30'N, long 92°28'E, 1300 m asl) in the Jaintia Hills district of Meghalaya, north-east India. For this study, 430 fresh seeds were collected, sealed in black plastic bags and transported to the laboratory. The seeds were stored at room temperature (25 ± 2 °C) and sown within 3 days to avoid loss of viability.

Seed germination and seedling growth

The effects of seed mass on seed germination, seedling survival and growth of *P. jenkinsii* were studied under laboratory conditions at the North-Eastern Hill University Campus, Shillong (Lat 25°34'N, long 9°54'E, 1450 m asl). Seeds of each of the 3 weight classes were separately soaked for 24 h in distilled water at room temperature (25 ± 2 °C). The soaked seeds were sown separately in 20 × 17 cm polythene bags filled with garden soil. Seeds were sown on 20 April 2002, and each bag supplied with 150 ml of tap water every 3 days to moisten the soil. Each seed was tagged to study its fate. Seedling emergence was recorded until seedlings ceased to emerge (150 days). A seed with a protruding radical of about 2 mm was considered germinated. The seedlings were allowed to grow for 1 year after germination for survival and growth studies.

Data analyses

There was a wide variation in seed weight, which permitted the categorization of seeds into 3 distinct weight classes, light (< 1.5 g), medium or intermediate (> 1.5-2 g) and heavy (> 2 g). Weights of individual seeds were determined by weighing 400 fresh seeds (30 damaged seeds were discarded) and a seed weight frequency distribution was generated that was compared for normality and tested by the K-S test. Growth performance of the seedlings was measured in terms of their height, leaf number, leaf area and dry weight by excavating 5 randomly selected seedlings from each of the 3 seed mass categories. The excavated seedlings were washed thoroughly with water to remove soil particles. Leaf area was measured using a LICOR-3000A leaf area meter (LICOR, Lincoln, Nebraska, USA). Dry matter yield was determined by drying the plant material to a constant weight in a 60 °C oven. Data were analysed by analysis of variance (ANOVA) and linear regression was computed according to Zar (1974).

Results

Seed weight

Seed weight (n = 400) ranged from 0.5 g to 2.72 g (mean weight: 1.63 ± 0.02 g). Light (< 1.5 g) seeds made up 53.5% of the seed population, followed by heavy (> 2 g) and intermediate seeds (> 1.5 < 2 g), which accounted for 27% and 19.5%, respectively. The distribution pattern of seed weight did not show lognormal distribution (K-S test: $P < 0.01$, $d = 0.158$, $n = 400$).

Seed germination

The overall germination of *P. jenkinsii* seeds was 34.25%; 28% of light-weight seeds germinated, as did 41% of intermediate-weight and 42% of heavy-weight seeds. Germination began on the 39th day and ended on 95th day for light-weight seeds, on the 49th day and 75th

day for intermediate-weight seeds and on the 131st and 135th day for heavy-weight seeds (Figure 1). Fifty percent of the germination was achieved on 50th, 75th and 100th day for light, intermediate and heavy seeds, respectively (Table 1). Germination time was positively correlated with seed weight (Figure 2).

Seedling survival and growth

Seedlings that arose from heavy-weight seeds showed 80% survival after 1 year of germination. The seedling survival was 62.5% for intermediate-weight seeds and 42% for light-weight seeds.

Seedling growth, measured in terms of shoot length, root length, number of leaves, leaf area and dry matter yield at the end of 1 year of germination, was significantly affected by seed weight ($P < 0.01$). Growth of seedlings from heavy seeds was significantly better than that from intermediate- and light-weight seeds (Table 2). The relationship between initial seed mass and seedling growth characteristics based on regression analysis indicated that seed mass promoted seedling vigour (Table 3).

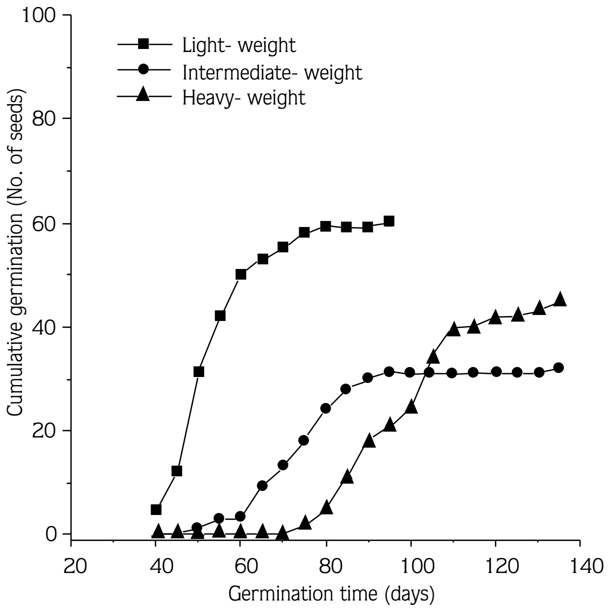

Figure 1. Germination curve of light-, intermediate- and heavy-weight seeds of *Prunus jenkinsii*.

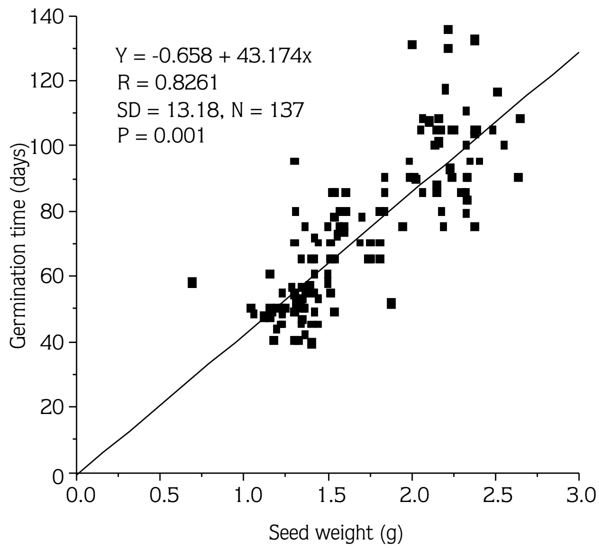

Figure 2. The relationship between seed weight and germination time in *Prunus jenkinsii*.

Discussion

Prunus jenkinsii, being a late successional coloniser, depends for regeneration on the availability of moist shady places that favour their seed germination, seedling establishment and growth. The difference in germination initiation times of the different seed weight classes seems to be an important trait of the species that helps them to colonise different microhabitats at different times. Seeds of *P. jenkinsii* mature by the middle of April and soon after are exposed to the rainy season when moisture is readily available and temperatures are relatively high. In

Table 1. Germination behaviour of light, intermediate and heavy seeds of *P. jenkinsii*.

Seed weight class (g)	Number of seeds sown (n)	Number of seeds germinated	Number of days for initiation of germination	Mean number of days for germination	50% germination
Light (< 1.5)	214	60 (28%)	39	53.78	50
Intermediate (> 1.5-2)	78	32 (41%)	49	75.53	75
Heavy (> 2)	108	45 (42%)	75	98.38	100

Table 2. Seedling survival, shoot and root length (cm), number of leaves/plant, leaf area (cm^2) and dry weight/plant (g) of *P. jenkinsii* seeds in light, intermediate-, and heavy-weight classes after 1 year of germination (ANOVA of the values are significant at $P < 0.01$, except the number of leaves/plant).

Seed weight (g)	Survival (%)	Shoot length (cm)	Root length (cm)	Number of leaves/plant	Leaf area (cm^2)	Dry weight /plant (g)
Light-weight (< 1.5)	41.67	11.8 ± 0.64	10.94 ± 1.03	3.6 ± 0.50	44.39 ± 3.18	0.291 ± 0.011
Intermediate-weight (> 1.5-2)	62.5	13.94 ± 1.01	10.88 ± 0.89	4.4 ± 0.50	65.37 ± 4.49	0.379 ± 0.022
Heavy-weight (> 2)	80	15.5 ± 0.60	11.68 ± 0.81	5.2 ± 0.37	73.34 ± 2.34	0.433 ± 0.013

Table 3. Seed weight influence on seedling characteristics in *P. jenkinsii*. Regression equation for the relationship between initial seed weight (n = 15), shoot and root length (cm), number of leaves/plant, leaf area (cm^2) and dry weight/plant (g).

Variables	Regression equation	r	P value
Shoot length	Y = 7.357 + 3.533x	0.750	0.001
Root length	Y = 9.413 + 0.969x	0.238	0.392
Number of leaves/plant	Y = 1.733 + 1.47x	0.594	0.01
Leaf area	Y = 18.139 + 23.724x	0.778	0.0006
Dry matter	Y = 0.145 + 0.122x	0.846	0.00007

such environmental conditions, seeds germinate and seedlings are established before the onset of winter. Heavier seeds confer an advantage to their seedlings for survival and growth due to their large reserves of nutritive substances (Tripathi & Khan, 1990; Ke & Werger, 1999; Khan et al., 1999, 2002; Khan & Uma Shankar, 2001). Tripathi & Khan (1990) and Barik et al. (1996) argued that seedlings emerging from seeds of varied mass grow at different rates. Seedlings of large and heavy seeds show better emergence, survival and growth than the seedlings of small seeds (Bonfil 1998), while light seeds confer the advantage of greater dispersal efficiency (Ganeshaiah & Shaanker, 1991; Hedge et al., 1991). A higher proportion of light-weight seeds contributes to wide dispersal, while heavy-weight seeds with the longest germination period and healthier seedlings may offer an advantage for its growth performance.

Wide intraspecific variation in seed mass is common in tropical tree species (Foster, 1986; Khan et al., 1999, 2002; Khan & Uma Shankar, 2001). Variation in seed weight clearly influences germination in *P. jenkinsii*. Light-weight seeds germinated earlier than did heavy-weight seeds under laboratory conditions. Similar results have been reported for other tropical tree species (Marshall, 1986; Murali, 1997; Khan et al., 1999); however, contradictory results have been reported for many species in which heavier seeds germinated earlier than lighter seeds (Tripathi & Khan, 1990; Barik et al., 1996; Vera, 1997; Khan & Uma Shankar, 2001), or germination was independent of seed size (Gross & Kromer, 1986; Perez-Garcia et al., 1995). In the present study, the thick coat of the heavier seeds might have caused late germination. The relatively large proportion of smaller seeds are easily dispersed and presumably preferred by predators; thereby pressures of predation on heavy seeds tend to decrease, which suggests a protection against predation for heavy seeds (Tripathi & Khan, 1990).

In *P. jenkinsii*, the seedlings from heavy seeds survived maximally and had greater height, leaf number, leaf area and dry matter yield than seedlings from intermediate- and light-weight seeds. Further, the positive correlation of seedling vigour with initial seed weight (Table 3) suggests that seedlings from heavy-weight seeds are more competitive. This finding agrees with Bonfil (1998) and Long & Jones (1996), who reported a positive correlation between seed mass and seedling survival and growth in *Quercus rugosa, Q. laurina* and 14 oak species.

Conclusions

It has been argued that whenever the environment consists of a favourable habitat, a parent does its best by producing only small offspring, and when conditions are reversed, production of larger offspring could be advantageous (McGrinley et al., 1987). In *P. jenkinsii*, the observed differences in seed germination, and seedling survival and growth due to seed size, indicate that the species differs considerably in its safe, microsite requirements. It also indicates that sufficient energy content of heavy-weight seeds helps in producing better performing seedlings compared to their counterparts (light- and immediate-weight seeds) and may be viewed as an important reproductive strategy.

References

Armstrong DP & Westoby M (1993). Seedlings from large seeds tolerate defoliation better: a test using phylogenetically independent contrasts. *Ecology* 74: 1092-1100.

Baker HG (1972). Seed weight in relation to environmental conditions in California. *Ecology* 53: 997-1010.

Balakrishnan NP (1981). *Flora of Jowai, Meghalaya*, Vol. I. Botanical Survey of India, Howrah.

Barik SK, Tripathi RS, Pandey HN & Rao P (1996). Tree regeneration in a subtropical humid forest: effect of cultural disturbance on seed production, dispersal and germination. *J Appl Ecol* 33: 1551-1560.

Bhuyan P, Khan ML & Uma Shankar (2000). Trade-off between dispersal efficiency and seedling fitness in *Oroxylum indicum*, a wind dispersed tropical tree. *Int J Ecol Env Sci* 26: 67-73.

Bonfil C (1998). The effect of seed size, cotyledon reserves, and herbivory on seedling survival and growth in Quercus rugosa and Q. laurina (Fagaceae). *Am J Bot* 85: 79-87.

Foster SA (1986). On the adaptive value of large seeds for tropical moist forest trees: a review and synthesis. *Bot Rev* 52: 261-299.

Foster SA & Janson SA (1985). The relationship between seed size and establishment conditions in tropical woody plants. *Ecology* 66: 773-780.

Ganeshaiah KN & Uma Shaanker R (1991). Seed size optimization in a wind dispersed tree *Butea monosperma*: A trade-off between seedling establishment and pod dispersal efficiency. *Oikos* 60: 3-6.

Gross KL (1984). Effect of seed size and growth form on seedling establishment of six monocarpic perennials. *J Ecol* 72: 369-387.

Gross KL & Kromer ML (1986). Seed weight effects on growth and reproduction in *Oenothera bennis* L. *Bull Torrey Bot Club* 113: 252-258.

Grubb PJ (1996). Rainforest dynamics: the need for new paradigms. In: Edwards DS, Booth WE & Choy SC (eds.), *Tropical Rainforest Research: Current Issues* pp. 215-233 Kluwer, Dordrecht.

Grubb PJ & Coomes DA (1997). Seed mass and nutrient content in nutrient-starved tropical rainforest in Venezuela. *Seed Sci Res* 7: 269-280.

Grubb PJ & Burslem DFRP (1998). Mineral nutrient concentrations as a function of seed size within seed crop: implications for competition among seedlings and defence against herbivory. *J Trop Ecol* 14: 177-185.

Haridasan K & Rao RR (1985). *Forest Flora of Meghalaya* Vol. I. Bishen Singh Mahendra Pal Singh, Dehradun, India.

Hegde SG, Ganeshaiah KN & Uma Shaanker R (1991). Fruit preference criteria by avian furgivores: their implications for the evolution of clutch-size in *Solanum pubescence. Oikos* 60: 20-26.

Kanjilal VN, Kanjilal PC, Das A, De RN & Bor NL (1997). *Flora of Assam* Vol. II Omsons Publications, New Delhi.

Ke G & Werger MJA (1999). Different responses to shade of evergreen and deciduous oak seedlings and the effect of acorn size. *Acta Oecol* 20: 570-586.

Khan ML, Bhuyan P, Uma Shankar, Singh ND & Todaria NP (1999). Seed germination and seedling fitness in *Mesua ferra* L. in relation to fruit size and seed number per fruit. *Acta Oecol* 20: 599-606.

Khan ML & Uma Shankar (2001). Effect of seed weight, light regime, and substratum microsite on germination and seedling growth of *Quercus semiserrata* Roxb. *Trop Ecol* 42: 117-125.

Khan ML, Bhuyan P, Singh ND & Todaria NP (2002). Fruit set, seed germination and seedling growth of *Mesua ferra* Linn. (Clusiaceae) in relation to light intensity. *J Trop Forest Sci* 14: 35-48.

Long TJ & Jones RH (1996). Seedling growth strategies and seed size effects in fourteen oak species native to different soil moisture habitats. *Trends in Ecol Evol* 11: 1-8.

Marshall DL (1986). Effect of seed size on seedling success in three species of *Sesbania* (Fabaceae). *Am J Bot* 73: 457-464.

McGinley MA, Temme DH & Geber MA (1987). Parental investment in offspring in variable environments: Theoretical and empirical considerations- *Am Nat* 130: 370-398.

Meyer SE & Carlson SL (2001). Achene mass variation in *Ericameria nauseosus* (Asteraceae) in relation to dispersal ability and seedling fitness. *Fun Ecol* 15: 274-281.

Murali KS (1997). Pattern of seed size, germination and seed viability of tropical tree species in Southern India. *Biotropica* 29: 271-279.

Perez-Garcia F, Iriondo JM & Martinez-Laborde JB (1995). Germination behaviour in seeds of *Diplotaxis erucoides* and *D. virgata*. *Weed Res* 35: 495-502.

Tripathi RS & Khan ML (1990). Effects of seed weight and microsite characteristics on germination and seedling fitness in two species of *Quercus* in a subtropical wet hill forest. *Oikos* 57: 289-296.

Vera ML (1997). Effects of altitude and seed size on germination and seedling survival of heath land plants in north Spain. *Plant Ecol* 133: 101-106.

Zar JH (1974). *Biostatistical analysis*, Englewood Cliffs, New Jersey: Prentice Hall.