Journal of Tropical Forest Science 10(1): 58 - 65 (1997)

REGENERATION OF *HOPEA PONGA* : INFLUENCE OF WING LOADING AND VIABILITY OF SEEDS

H. Muralikrishna & K.R. Chandrashekar*

Department of Applied Botany, Mangalore University, Mangalagangothri - 574 199, India

Received November 1995

MURALIKRISHNA, H. & CHANDRASHEKAR, K.R. 1997. Regeneration of *Hopea ponga* : influence of wing loading and viability of seeds. Studies on wing loading and vertical settling time of *Hopea ponga* did not indicate a direct correlation between the two factors. Germination studies of *H. ponga* showed 96% germination of the seeds sown immediately after collection, which decreased through time with desiccation. After 12 days of storage, seeds lost 39% of the initial moisture content and were not viable; thus the recalcitrant behaviour of the seeds is established. The higher germination percentage in heavier and lighter seeds may be responsible for clumped formations and invasion into newer areas respectively.

Key words: *Hopea ponga* - seed dispersal - viability - recalcitrant seeds - clumped formations - regeneration

MURALIKRISHNA, H. & CHANDRASHEKAR, K.R. 1997. Pemulihan *Hopea ponga* : pengaruh muatan angin dan kebolehidupan biji benih. Kajian mengenai muatan angin dan masa pemendapan tegak *Hopea ponga* tidak menandakan perkaitan secara langsung di antara kedua-dua faktor. Kajian mengenai percambahan *H. ponga* mempamerkan 96% biji benih yang dicambah terus ditanam selepas kutipan, berkurangan selepas pengeringan. Selepas penyimpanan selama 12 hari, biji benih kehilangan 39% daripada kandungan awal kelembapan dan tidak bernas dengan itu tingkah laku rekalsitran biji benih berlaku. Peratus percambahan yang lebih tinggi dalam biji benih yang berat dan yang ringan masing-masing bertanggung jawab bagi pembentukan dan penyebaran rumpun ke kawasan lain.

Introduction

Tree species belonging to the family Dipterocarpaceae are being continuously exploited for timber, fire wood, plywood and other uses. Neither a scientific knowledge of germination and viability behaviour of the seeds nor any information on the clumped formations of the species of Dipterocarpaceae endemic to the Western Ghats of India is available. Fruitfall during dry seasons, not followed by subsequent regeneration, leads to a conjecture that the seeds are recalcitrant. According to Roberts (1973), seeds of certain species which suffer from damage on desiccation below a critical level cannot be stored for long periods. Such seeds are called recalcitrant. It is widely believed that seeds

**Author for correspondence.*

of many species of Dipterocarpaceae are generally short-lived and incapable of overcoming desiccation (Chan 1980, Sasaki 1980, Nautiyal & Purohit 1985a, Tompsett 1987, Saha *et al.* 1992). Wing loading, as a cause for limiting seed dispersal, has been well reported in different wind dispersed species (Augsperger & Hogan 1983, Ganeshiah & Shaanker 1988, 1991), but there is only one ecological report on the occurrence of clumped formations and invasion of *Hopea ponga* into newly exploited areas (Pascal 1989).

The present study investigated the germination, viability, vertical settling time of the seeds of *H. ponga* with respect to wing loading and the relationship between seed weight and seedling survival.

Materials and methods

The seed

Seeds of *Hopea ponga* (Dennst.) Mabb. (Syn: *H. wightiana* Wall.) were used in the study; (the single ovoid seeded fruit with two wings opposite to each other, which are flat and thin leaf-like expansions of the sepals is referred to as seed throughout this paper). The species is endemic to southwestern India and distributed throughout the Western Ghats.

Seed collection

About 5 kg of seeds were collected from 20- to 25-y-old trees which were growing near Mangalore during May 1994. Seeds already fallen on the floor were removed before collection of the fresh seeds. The branches were shaken at the time when the fruit wings turned brown and the seeds that dropped were gathered from the ground (Masano 1991) and immediately brought to the laboratory for study. One thousand seeds without wings weighed 348 g.

Wing loading and vertical settling time

The wing was placed on graph paper, its margin was outlined and the area was obtained by counting the squares (Kvet & Marshall 1971). Seed weight was determined using a Mettler AE 50 precision balance. Wing loading was calculated as surface area of wings divided by the weight of the seed (Green 1980). The vertical settling time was determined by noting the time taken by the seed to reach the ground in still air from a height of 15 m. Statistical analysis was carried out using the computer programme with a linear regression formula $y = A+Bx$.

Viability and germination

After removing the wings and washing in distilled water, seeds were germinated on sandbeds, moistened with distilled water and prepared in polyesterine trays.

Ovoid seeds of *c.* 0.5 cm size were sown vertically with the germpore pointing upwards in order to simulate natural condition. Seeds with protrusion of radicle were counted as germinated. The conditions provided for germination were normal laboratory conditions (25 - 35 °C, 65 - 70% R.H.) and usual day and night illumination course (13/11 h respectively for day/night). To record the viability of seeds, the seeds were spread on a mat in the laboratory, and 400 seeds were taken on alternate days and sown after removing the wings. Germination count was made after a week of sowing. The data on survival of seedlings after 30 days were considered as rate of seedling establishment.

Comparison of seed weight and survival

In order to study the relationship between seed weight and seedling survival, the seeds were classified from a total of 400 into five classes based on the weight of the seeds and allowed to germinate on sandbeds in polyesterine trays. The survival of the seedlings was recorded six months after sowing. The data were analysed using chi-square test.

Results

Wing loading and vertical settling time

Wing loading was plotted against the vertical settling time of the fruits (Figure1). The vertical settling time was higher for higher wing loading, but from the slope ($r^2 = 0.01$), dependence of the former on the latter was very low even though both were positively correlated. Plotting fruit weight against settling time (Figure 1) also indicates little significant relationship ($r^2 = 0.04$) between the two. Increasing wing area and/or decreasing seed weight results in a delayed settling of seeds, but this relationship is statistically not significant.

Viability and germination

The seeds of *Hopea ponga* sown on sandbeds germinated within 24 h. The emerged radicles, pale pinkish in colour which initially grew vertically upwards turned positively geotrophic the next day. The cotyledons separated at the time of emergence of the plumule, and later so was the seedcoat. Wherever the seed coat was not pushed off by the plumule, the seedlings did not show any further growth (Figure 2). The seedlings with swollen hypocotyl and weak radicle also did not show further growth.

The results on the germination of seeds, water loss and survival of the seedlings after storing for different periods are shown in Figure 3. The seeds sown immediately after the collection showed 96% germination and 34% survival. Thereafter, germination percentage decreased. The seeds stored for 12 days did not germinate and had lost 39% of their fresh weight. The seeds sown immediately after the collection showed higher percentage of survival which gradually decreased with increased storage time. The seeds that germinated on the tenth day did not establish.

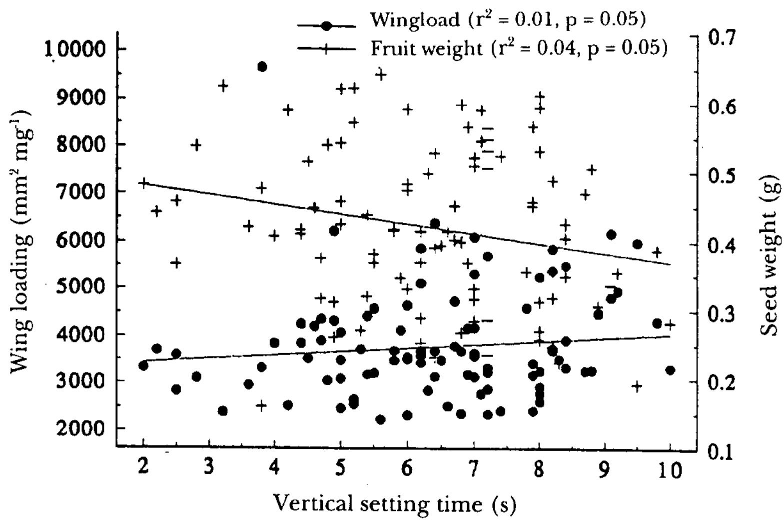
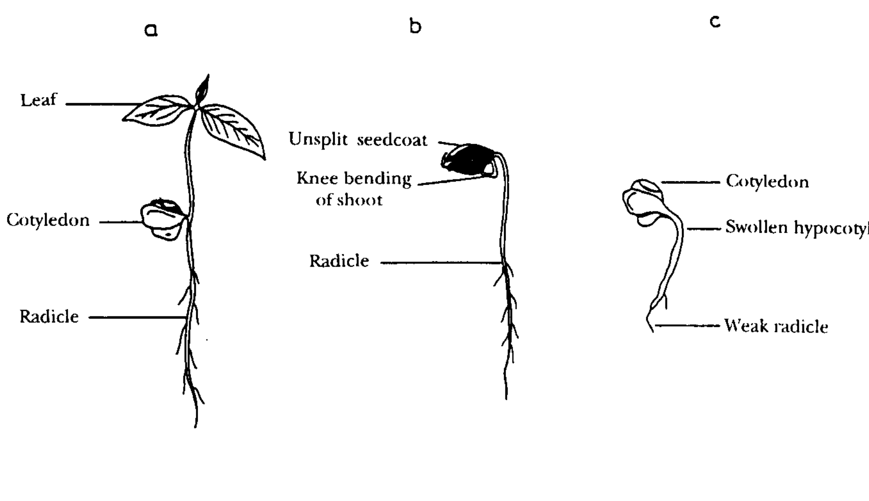


Figure 1. Wing loading and seed weight versus vertical settling time of *H. ponga*



(a) Normal seedling
(b) Abnormal seedling with unsplit seedcoat, and
(c) With swollen hypocotyl and weak radicle

Figure 2. Seedlings of *H. ponga*

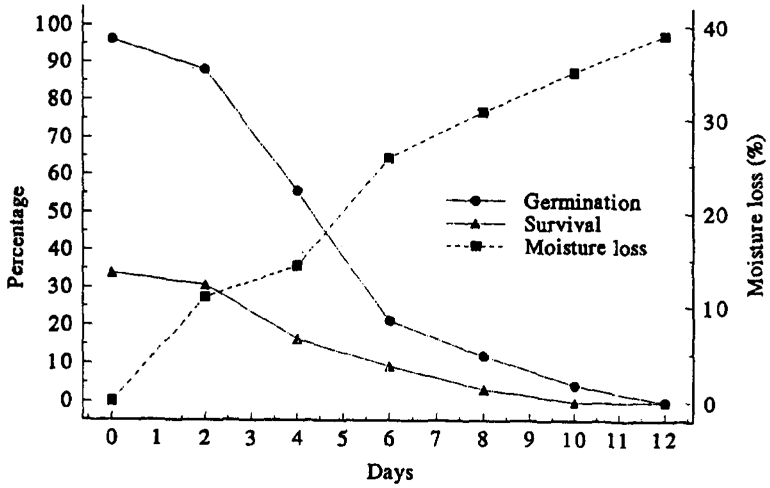


Figure 3. Time-course study of percentage germination, seedling survival and moisture loss during storage of *H. ponga*

Comparison of seed weight and survival

The data on survival of seedlings from the seeds belonging to different weight classes are shown in Table 1. Out of 400 seeds a maximum of 32 % showed a weight of between 0.3 and 0.4 g. The percentage survival was maximum in the seeds belonging to the extreme weight classes.

Table 1. Relationship between seed weight and seedling survival in *H. ponga*

Weight class no.	Weight range (g)	Total number of seeds	No. survival	Percentage survival
1	0.1-0.2	48	24	50.0
2	0.2-0.3	88	38	43.2
3	0.3-0.4	128	28	21.9
4	0.4-0.5	92	44	47.8
5	0.5-0.6	44	24	54.5
Total		400	158	39.5

Note: Chi-square(observed)=26.189; chi-square(tabled)=11.070.

Discussion

The distribution of *Hopea ponga* throughout the belt of southwestern India is clumped at places and often gregarious in patches. Seedling regeneration in clumps around the mature plants within a forest formation is also a common feature in this species. In the present investigation, the influence of wing loading and seed weight on vertical settling time was not statistically significant. The dispersal of the seeds under natural conditions involved the horizontal swinging of these spinning winged seeds, which is likely to be proportional to the wind speed. Since the wind speed in dense canopies is low, chances of settling of the heavier seeds near the parent plants are better. However, it is obvious that during the monsoon, when the wind speed is of about 40 km h^{-1}, seeds produced tend to be dispersed to newly exploited/cleared neighbourhood areas, as also reported by Pascal (1989). In the present experiment it is evident that the germination percentage was higher for seeds falling in the extreme weight classes. Moore (1993) noted the ecological advantage of the larger size of seeds in favouring the production of healthier seedlings and clumped formations. Seed mass in limiting the dispersal of winged seeds was studied in *Butea monosperma* by Ganeshaiah and Shaanker (1991) who showed that seed mass, as a factor in wing loading, contributes to selection by favouring a pattern of seedling establishment. In *H. ponga* clumped distribution of the plants may occur because of the natural selection of the heavier seeds during the course of time, as there is no report on controlled selection in this species. The invasion of *H. ponga* into newly exploited/cleared areas may also be favoured by the production of lighter seeds having higher survival rate.

A high germination of 96% in this species corresponds to the observations on other species of the Dipterocarpaceae by earlier workers. Tompsett (1987) observed 100% germination in *Dipterocarpus obtusifolius* and about 90% in *D. alatus* and *D. tuberculatus*. In *Hopea odorata*, Huang and Villanueva (1993) observed almost 100% germination.

In nature seeds not only experience drying due to lack of showers but also cycles of wetting and drying due to showers followed by sunny days (Mustart & Cowling 1993). Therefore, the authors are of the opinion that the storability of the seeds differs depending on the climate prevailing after the fruit fall. In the present study the degree of establishment of the seedlings under normal laboratory conditions was 34% for a 96% germination. The low level of establishment may be attributed to the development of abnormal seedlings such as those with unsplit seedcoat and swollen hypocotyl and weak radicle.

Sequential but quick loss of moisture content in the seeds stored under normal laboratory conditions was experienced in the present experiment. The germination percentage declined below 60% after the second day of storage and reached zero by the twelfth day with a loss of 39% moisture content whereas survivability reached zero by the tenth day of storage with a loss of 35% moisture content. This observation obviously indicates that the seeds are recalcitrant. The results of the present experiment corroborate with the report of Tompsett (1987) who observed a 40-60% loss of moisture content among *Dipterocarpus* species with a consequential loss of viability. The reasons for loss of viability due to desiccation have been elaborately discussed by Nautiyal and Purohit (1985a, b) for *Shorea robusta.* The sequential loss of moisture content damages the cellular membrane resulting in the loss of its semipermeable character as evidenced by the increase in solute leachates, and it is predicted that the damage to the membrane once happened is irreparable with further hydration. Studies on the maintenance of moisture content and rehydration of the seed to protect its structural and biochemical integrity are relevant to extend the viability of the species.

Conclusion

The occurrence of clumped formations of *H. ponga* may be due to the settling of seeds around the mother tree and higher germination capacity of the heavier seeds. Abundant fruiting, which can occur at any time during the year, may prove futile in the absence of rains because the seeds are recalcitrant.

Acknowledgements

The authors are grateful to K.M. Kaveriappa, Chairman of the Department of Applied Botany for providing the facilities to carry out this work, B. Chempakam, Scientist, IISR, Kozhikode for critical reading of the manuscript, and two anonymous referees for their comments.

References

AUGSPURGER, C.K. & HOGAN, K.P. 1983. Winged dispersal of fruits with variable seed number in a tropical tree (*Lonchocarpus pentaphyllus*: Leguminosae). *American Journal of Botany* 70: 1031 - 1037.

CHAN, H.T. 1980. Reproductive biology of some Malaysian dipterocarps. II. Fruiting biology and seedling studies. *Malaysian Forester* 43 : 438 - 451.

GANESHAIAH, K.N. & SHANKER, R.U. 1988. Seed abortion in wind dispersed pods of *Dalbergia sissoo* : material regulation or sibling rivalry? *Oceologia* 77 : 135 - 139.

GANESHAIAH, K.N. & SHAANKER, R.U. 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.

GREEN, D.S. 1980. The terminal velocity and dispersal of spinning samaras. *American Journal of Botany* 67 : 1218 - 1224.

HUANG, H. & VILLANUEVA, V.R. 1993. Amino acids, polyamines and proteins during seed germination of two species of Dipterocarpaceae. *Trees* 7 : 189 - 193.

KVET, J. & MARSHALL, J.K. 1971. Assessment of leaf area and other assimilating plant surfaces. Pp. 517 - 555 in Sestak, Z., Catsky, J. & Jarvis, P.G. (Eds.) *Plant Photosynthetic Production. Manual of Methods.* Dr. W. Junk N.V. Publishers, The Hague, Netherlands.

MASANO, P. 1991. The effect of wing colour on the germination of *Shorea pinanga* and *Shorea stenoptera* seeds. *Seed Abstracts* 14 (87).

MOORE P.D. 1993. For richer, for poorer. *Nature* 366 : 515.

MUSTART, P.J. & COWLING, R.M. 1993. Effects of soil and seed characteristics on seed germination and their possible roles in determining field emergence patterns of four Agulhas Plain (South Africa) Proteaceae. *Canadian Journal of Botany* 71: 1363 - 1368.

NAUTIYAL, A.R. & PUROHIT, A.N. 1985a. Seed viability in sal. II. Physiological and biochemical aspects of ageing in seeds of *Shorea robusta*. *Seed Science and Technology* 13 : 69 - 76.

NAUTIYAL, A.R. & PUROHIT, A.N. 1985b. Seed viability in sal. III. Membrane disruption in ageing seeds of *Shorea robusta*. *Seed Science and Technology* 13 : 77 - 82.

PASCAL, J.P. 1989. *Wet Evergreen Forests of the Western Ghats of India*. Institut de Françai's de Pondicherry. 345 pp.

ROBERTS, E.H. 1973. Predicting the storage life of seeds. *Seed Science and Technology* 1: 499 - 514.

SASAKI, S. 1980. Storage and germination of dipterocarp seeds. *Malaysian Forester* 43 : 290 - 308.

SAHA, P.K., BHATTACHARYA, A. & GANGULY, S.N. 1992. Problems with regard to the loss of seed viability of *Shorea robusta* Gaertn. *f.* *Indian Forester* 118 : 70 - 76.

TOMPSETT, P.B. 1987. Desiccation and storage studies on dipterocarp seeds. *Annals of Applied Biology* 110 : 371 - 379.