Effect of seed mass and light intensity on seedling success of *Mesua ferrea* Linn.

The seed of a higher plant is in fact an embryo plant produced in a fruit after the union of male and female sex cells. A seed is in fact an embryo plant and contains within itself virtually all the materials and energy to develop into a new plant. Germination is the growth of an embryonic plant contained within a seed, which results in the formation of a seedling. But seeds require the right conditions to exhibit successful germination and growth. It is in fact dependent on both internal and external conditions. The most important external factors include: temperature, water, oxygen and sometimes light or darkness[1]. Most of the seeds usually prefer to develop in a steady and less fluctuating temperature. Light-effect I induces a chain of events leading to gibberellic acid (GA) biosynthesis. Light-effect II seems to enhance the sensitivity of the seeds to GAs[2]. In addition, the role of seed size and weight of tree seed in seedling performance is also of great importance. The wide differences in seed mass among species have been regarded as an important aspect of the reproductive strategy[3]. The seed size had a clear effect on survival, with seedlings from large seeds having the highest survival[4]. Large-seeded species have an advantage in competitive environments[5].

A study was conducted on *Mesua ferrea* Linn. (family Guttiferae) to investigate the collective effect of seed weight and light intensity upon germination, as well as growth and development. A total of 500 fruits of *M. ferrea* were collected from the Tezpur University campus during August–October 2008. The seeds were removed from the fruits and categorized into three weight groups, namely group 1: 0.5–2.5 g; group 2: > 2.5–3.5 g and group 3: 3.5–5.5 g. A total of 887 seeds were obtained from these 500 fruits; 231 fruits were single-seeded, 175 were two-seeded, 70 were three-seeded and 24 fruits were four-seeded. Considering the weight of seeds, highest seeds were obtained in group 2 having 400 seeds and lowest in group 3 having 234 seeds.

The experimental work was conducted inside the Tezpur University campus during November 2008–April 2009 at three different sites (I–III), which varied in the intensity of sunlight falling on them. Site I received a range of light intensities (μmol m^{-2} s^{-1}) varying from 9.86 to 877.82; site II received within 7.78–771.45 and site III received between 6.36 and 602.45. Thirty seeds of more or less similar seed weight were randomly selected from each of the three different seed-weight groups and sown individually in experimental culture pots (30 cm × 30 cm) in November 2008. The experimental culture pots were kept in the three study sites. Each site had 90 pots (30 + 30 + 30) having 30 seeds of each of the three seed-weight groups that were sown for germination. Soil used in the culture pots had pH 6.5, bulk density 1.42 g cm^{-3}, water-holding capacity 39.6%, nitrogen content 0.0173%, exchangeable phosphorus 0.08 ppm, exchangeable potassium 130.3 ppm, organic carbon 0.093% and nitrate content 0.024%. The average minimum temperature during the study period was 15.77°C and maximum temperature was 26.90°C; rainfall varied from 0 to 34.13 mm and the average relative humidity was 72.33%.

Germination of seeds was observed after 15 days of sowing. The growth and survival of seedlings were observed weekly for a period of 3 months (February–April 2009). Stem height, collar diameter (basal area) and leaf number of all the seedlings were measured during each time of observation. Relative growth rates of the individual seedlings in terms of relative growth rate for height (RGRH) and basal area (RGRB) were calculated[6].

The results have shown that collected seeds of *M. ferrea* vary across 0.5 to 5.5 g, i.e. over a range of 5 g in terms of seed weight and that the viability of the seeds is correlated with their weight. It indicates that greater the weight, greater is the probability of germination and survival[7,8]. This in turn indicates that larger seeds have greater resources to initiate the process of germination. Another important factor in the process of germination was the intensity of falling light[9]. Majority of the seeds were germinated in the later part of February 2009, after the sowing of seeds on 21 November 2008. Germination was highest in site III, followed by sites II and I. The percentage of seed germination in site III was the best for the seed-weight group 2, followed by seed-weight group 3; however the rate of germination among the three seed-weight groups was not significantly different ($F = 18.05$; $P < 0.05$). On the other hand, in the case of sites I and II, the situation was reversed. This in turn shows that higher the seed weight, more is the resistance to high intensity sunlight, and also indicates that sufficient energy is contained in the seeds to promote the emergence of seedlings and their ability to sustain themselves until they grow high enough to support themselves photosynthetically[10]. It has been found that seeds having weight between > 2.5 and 3.5 g showed the greatest percentage of germination followed by seeds weighting between > 3.5 and 5.5 g. However, the lighter seeds weighting 0.5 and 2.5 g exhibited the least degree of germination. However, the overall performance of the seeds of all the seed-weight groups was best in site III, which may be due to low light intensity that must have protected the developing seedlings from extremely high temperatures[7]. In fact it has been found that greater the intensity of receiving light, lesser is the probability of germination in *M. ferrea*. Hence it can be concluded that *M. ferrea* is a shade-loving plant when it is young[11,12]. High temperatures achieved by soils exposed to full sun[13], water stress and oligotrophism[14] could be the limiting factors for establishment of seedling. It has also been found that the seeds of *M. ferrea* are not likely to germinate at very low temperatures. They usually prefer an average day temperature of about 16.5°C, with the minimum temperature not falling at least below 15.5°C. Hence the probability of germination to occur is much less in December and January, when the temperatures are low. As far as the relative humidity is concerned, more germination is likely to take place when the humidity is at a moderate level of about 50–60%.

The difference in the average number of leaves in the seedlings developing from different seed-weight groups is also considerable in all the study sites. The average number of leaves was found to be highest in site II, followed by sites I and III. The average number of leaves ranged from 3 to 4, 4 to 7 and 2 to 5 in sites III, II and I respectively, during April 2009. Significant variation in terms of leaf number has been recorded ($F = 0.21$; $P < 0.05$) in site III. Also, the number of leaves depends upon the light conditions, and seedlings developing in site II tend to have higher number of leaves. Seedlings that are damaged because of physical injury or eaten by insects tend to have greater number of leaves at a lesser height.

In site III the relative growth rate in terms of height gradually decreased by the end of the observation period (Figure 1). The height generally increases by about 1.5 cm in a week. The gradual increase in the rate of growth in terms of height towards the month of April may be due to higher relative humidity, particularly in site I having low light intensity[15,16]. Among the different seed-weight groups in site III, the plant height response was significantly different ($F = 127.42$; $P < 0.05$). For site II no remarkable response was exhibited by the seedlings with respect to the physical conditions prevailing during the study period. Gradual decrease of the relative growth rate in terms of height in site III may be because the plant is shade-demanding, particularly during the younger stage[11,12,17]. The relative growth rates in terms of height were significantly different among the three sites having different light intensities ($F = 0.425$; $P < 0.05$). At the same time, the relative growth rates in terms of height differed significantly according to the weight of the seeds ($F = 0.017$; $P < 0.05$). Seed-weight group 2 exhibited enhanced seedling developed in all the three study sites, and it was found to be the highest in site III which received low light intensity.

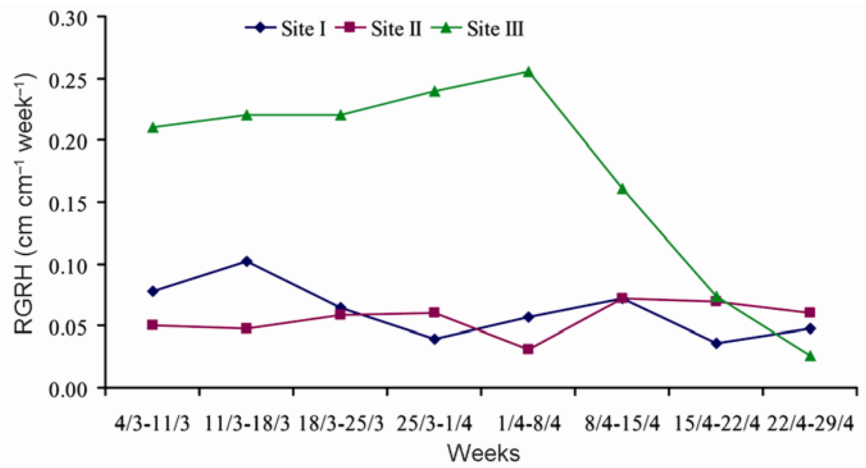

Figure 1. Relative growth rate in terms of height (RGRH) of *Mesua ferrea* growing in three different sites of varied light intensities.

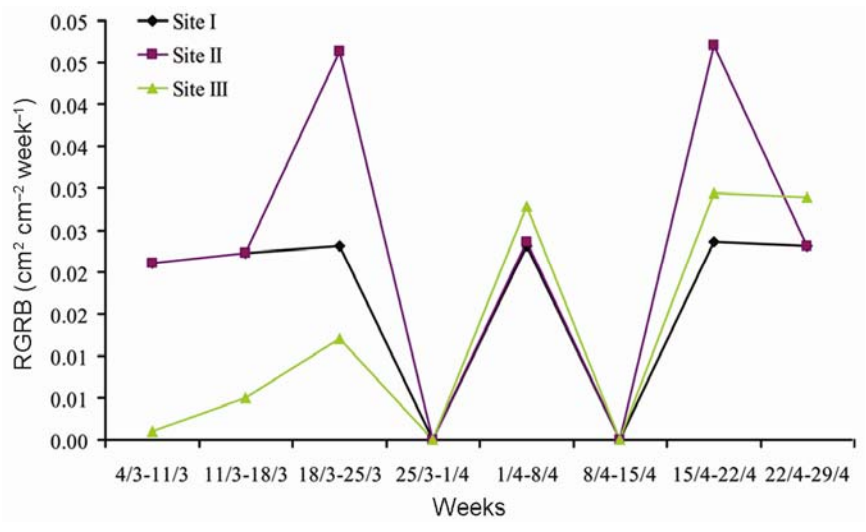

Figure 2. Relative growth rate in terms of basal area (RGRB) of *M. ferrea* growing in three different sites of varied light intensities.

Weekly increment of relative growth rate in terms of basal area was slow. Relation between seed-weight groups and increase in basal area was not significantly different ($F = 1.272$; $P < 0.05$) in site III. The growth rate was remarkably reduced in the fourth week of March as well as in the second week of April in all the three sites. But there were two peaks in the increase of basal area for all the sites, as shown in Figure 2 for the third week of March and second week of April. Site II exhibited better increment in basal area compared to the other two sites. RGRB showed fluctuation throughout the study period, but exhibited no or little growth with the increment rate of 0.02–0.46 cm. These may be due to the response towards some physical stress like changing relative humidity and rainfall in addition to physiological factors of the plant itself during these developmental stages.

It has been well established that *M. ferrea* is a shade-loving plant when young, since the plant shows better growth and development in a shady area or understorey which holds low intensity of sunlight. In fact, lesser the intensity of the solar radiation received, greater is the germination rate. High temperatures achieved by soils exposed to sun and water stress could be the limiting factors for seedling establishment. On the other hand, seed weight is also an important factor that affects germination, as the lighter seeds exhibited least rate of germination. Heavy seed weight might be having enough resource materials required for germination and seedling establishment. However, light not only influences seed germination but also the pattern of seedling development in terms of relative growth rate (plant height and collar diameter) as well as the number of leaves developed.

1. Raven, K., Peter, H., Ray, F. E. and Susan, E. E., *Biology of Plants*, W.H. Freeman and Company, New York, 2005, 7th edn, pp. 504–508.
2. Henk, W. M. H. and Cees, M. K., *Plant Physiol*., 1998, **86**(2), 591–597.

3. Grubb, P. J., In *Tropical Rainforest Research* (eds Edwards, D. S., Booth, W. E. and Choy, S. C.), Kluwer, Dordrecht, The Netherlands, 1996, pp. 215–233.
4. Saeed, S. and Shaukat, S. S., *Pak. J. Biol. Sci*., 2000, **3**(2), 292–295.
5. Gross, K. L., *J. Ecol*., 1984, **72**, 369–387.
6. Hunt, R., *Plant Growth Curves: The Functional Approach to Plant Growth Analysis*, Edward Arnold, London, 1982, p. 248.
7. Lafond, G. P. and Baker, R. J., *Crop Sci*., 1986, **26**, 341–346.
8. Arunachalam, A., Khan, M. L. and Singh, N. D., *Turk. J. Bot*., 2003, **27**, 343–348.
9. Khan, M. L. and Shankar, U., *Trop. Ecol*., 2001, **42**(1), 117–125.
10. Upadhaya, K., Pandey, H. N. and Law, P. S., *Turk. J. Bot*., 2007, **31**, 31–36.
11. Khan, M. L., Bhuyan, P., Uma Shankar and Todaria, N. P., *Acta Oecol*., 1999, **20**, 599–605.
12. Khan, M. L., Bhuyan, P., Singh, N. D. and Todaria, N. P., *J. Trop. For. Sci*., 2002, **14**(1), 35–48.
13. Franco, A. C. *et al*., *Trees Struct. Funct*., 1996, **10**, 359–365.
14. Reinert, F., Roberts, A., Wilson, J. M., Ribas, L., Cardinot, G. and Griffits, H., *Acta Botanica*, 1996, **109**, 1–8.
15. Ford, M. A. and Thorne, G. N., *Ann. Bot*., 1974, **38**, 441–452.
16. Leuschner, C., *Flora – Morphol., Distrib., Funct. Ecol. Plants*, 2002, **197**(4), 262–274.
17. NIIR Board., *Modern Technology of Oils, Fats and Its Derivatives*, National Institute of Industrial Research, Delhi, 2009, pp. 151–153.

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Expression of four-seeded pod in soybean

Four-seeded pod (SP) was expressed in all the 15 nodes of the soybean variety JS 90-41 with overall frequency of 42% and high expression of 68% in distal one-third part of the plant and specifically at the 14th node (80%). Maximum seed weight (115 mg) was recorded in two-, three- and four-SP located on node 3rd and 5th. The mean seed weight of four-SP was 96 mg, which was 6 and 5 mg less than the mean seed weight of three- and two-SP. Four-SP had 78 mg gain over three-SP; 182 mg gain over two-SP and 288 mg gain over one-SP. There was significant increase in seed yield with the increase in the frequency of four-SP in comparison to three- and two-SP. The overall plant basis four- and three-SP follow 1 : 1 ratio (χ^2 = 2.9) with 3 : 1 ratio in distal; 1 : 1 middle and 1 : 3 basal parts. Penetrance of 4 SP was nearly 50% at the plant level, with high expressivity in the distal, but low in the basal part of the plant. Higher yield of soybean may be achieved through hybridization between lines that have heavy top and heavy bottom with high penetrance of four-SP.

Seed per pod and its weight are the important yield-contributing traits of soybean (*Glycine max* (L.) Merrill), with peculiar phenotypic variable expressivity. Expression of 2–3 seeds/pod is common in soybean. The most popular variety of soybean in India, JS 335 is a puberulent and purple-flowered variety with more frequency of three-SP in comparison to two-SP, whereas the other variety JS 71-5 (denotified) had more frequency of two-SP puberulent pod in comparison to three-SP[1]. A few plants with increased frequency of four-SP were identified in a segregating generation derived from the interspecific cross of cultivated soybean, *G. max*, with its proposed wild progenitor *Glycine soja* (Seib. & Zucc.)[2]. One of its lines was notified as JS 90-41. The inheritance of four-SP in crosses originating from an EMS-derived mutant with its parental cultivar, indicated control of single recessive locus with a segregation ratio of 3 : 1 (low to high seeds per pod values) with confirmation by subsequent analysis of the $F_{2:3}$ families[3]. Morphological marker, narrow leaflet and microsatellite marker Sat_107 had close linkage with the locus responsible for four-SP (3.2 ± 1.11 cM) and both were effective in selecting the four-SP trait, although with different efficiencies[3]. From the breeding point of view, the number of seeds per pod and its weight

Table 1. Difference in mean weight (mg) of seeds formed in four-, three-, two- and one-seeded pod (SP) in soybean

Number of seeds/pod	Mean weight of single seed (mg)* (gain or loss in comparison to seeds/pod)			
	4	3	2	1
4	**096**			
3	–06	**102**		
2	–05	+01	**101**	
1	00	+06	+05	**096**

*Diagonal bold value.

Table 2. Total gain/loss (mg) by the extra seeds formed in four-, three- and two-SP in soybean

Number of seeds/pod	Total gain/loss (mg) (Number of seeds/pod)		
	4	3	2
3	+78 (–18 + 96)		
2	+182 (–10 + 192)	+104 (+02 + 102)	
1	+288 (00 + 288)	+201 (+06 + 204)	+106 (+05 + 101)