

## Effect of Seed Orientation, Media and Container Types on Germination Behaviour and Seedling Growth of *Swietenia macrophylla* King under Nursery Conditions

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**ABSTRACT** A study was undertaken in the nursery at Kerala Forest Research Institute, Peechi (10° 31' N latitude and 76° 20' E longitude; Mean annual rainfall 2700 mm; Mean annual temperature 18° C to 38.4° C) to test the effect of seed orientation, media and container types on germination and seedling growth of *Swietenia macrophylla* King. Seeds were sown in three different positions. Orientation of seeds during sowing had significant effect on germination of seeds as well as seedling growth. Sowing the seeds horizontally with the micropyle oriented laterally gave the maximum germination of 92 per cent as against 87 per cent by vertical sowing. But seeds sown inverted with the micropyle positioned upwardly gave only 11 per cent germination. Similarly, plant percentages were also higher in horizontal sowing (92%) than in vertical (82%) and inverted sowings (11%). Seeds were also sown in three different germination media such as river sand, garden soil and vermiculite. Although, there is no statistical difference between media on seed germination and subsequent seedling growth, obviously there is a difference between them. River sand medium was superior (98%), followed by garden soil (95%) and vermiculite (93%). Both the seed orientation and germination media significantly affected the rate of germination also. Earliest germination was observed in horizontal position sowing (13 DAS) followed by vertical (14 DAS) and inverted positions (19 DAS). Similarly, earliest germination was observed equally in river sand and garden soil (12 DAS) and culminated on 22 DAS. In vermiculite, seedling emergence was little delayed (15 DAS) and prolonged for sometime (29 DAS). Also incidence of abnormal seedlings was high in vermiculite medium (5.3%) than in garden soil (2.6%) and river sand (1.3%) media. Different containers did affect the growth of seedlings in the nursery. Polypotted seedlings are ready for field planting after 3 months while root trainer seedlings after 5-6 months. However, the polypotted seedlings can be kept for up to 5 months in the nursery since root coiling occurs afterwards where as root trainer seedlings can be kept for more than one year in the nursery.

**Key words :** Germination, seedling growth, *Swietenia macrophylla*

All seed embryos possess an innate ability to orient themselves and grow according to gravity. In some seeds, however, orientation during sowing influences germination. Most seeds are somewhat asymmetrical in shape and hence these are not likely to fall with the radicle end upwards or downwards during natural dispersal. For example, flat seeds tend to lie on the soil in a horizontal position, so that the radicle as well

as hypocotyl in most cases needs to change direction only 90° during germination. Hence during sowing practices where seeds are broadcast on seed-beds, only very few seeds are likely to be placed inversely, and no measures are necessary to assure correct orientation. While large seeds are often sown by dibbling each individual seed directly in containers such as polythene bags, root trainers, earthen pots, etc.,

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here correct or incorrect orientation of the seeds may influence germination [1]. Failure of seeds to germinate or seedlings to emerge have been found in some plants due to soil types and orientation of seeds at the time of sowing in nursery beds in a number of species [2-7].

*Swietenia macrophylla* King (Meliaceae) commonly known as 'large leaved mahogany' is a popular plantation species in the tropics and subtropics. It is distributed more widely ranging from southern Mexico throughout the Atlantic region of Mesoamerica, reaching its southern limit in Brazil [8]. Since its introduction into India in 1872, it has been extensively cultivated in gardens, along roadsides and railway tracks as an avenue tree and in forest areas mainly for its high quality timber [9]. Besides, it has also been planted to restore the ecologically degraded lands, to conserve the soil [10] and to establish green belts around industrial areas. It is propagated mainly through seeds that lose viability within three months under ambient room conditions and humidity [8]. Natural regeneration of this species is poor except in favourable localities. Further, it has neither seed nor seedling banks. Artificial regeneration is limited due to low seed production, short viability and unavailability of seeds.

The development of mahogany seedlings has been recorded earlier to have correlation with the position of seed during sowing in the seed-beds earlier [8, 11-17], but their results were inconsistent. Although there is some contradictory evidence and documentation of the practical importance of seed orientation during sowing is poor, it is advisable to orient the seeds with the radicle end (micropyle) down where seeds are sown individually. Likewise, where the micropyle is difficult to identify, oblong and flat seeds should be placed in a horizontal position. Irrespective of the less availability of mahogany seeds, short viability etc. this species has gained much importance in different forestry activities and hence, it is necessary to produce and manage large quantities of high quality planting material. Therefore, in order to develop nursery packages for *Swietenia macrophylla*, a study was undertaken at Kerala Forest Research Institute, Peechi (10°

31' N latitude and 76° 20' E longitude; Mean annual rainfall 2700 mm; Mean annual temperature 18° C to 38.4° C) to standardize the germination media, orientation of seed in the seed-bed during sowing and the influence of container types on seedling growth in nursery so that healthy and plantable seedlings could be produced.

## MATERIALS AND METHODS

### *Effect of seed orientation and media on germination and seedling growth*

The capsules were harvested from tree tops when a few capsules started to dehisce from a 10 year old tree at Peechi, in Thrissur District, Kerala State of India during the second-week of January 2001. When the capsules begin to split open, seeds were extracted and their wings removed manually. Moisture content of seeds was determined by drying the seeds in an hot air oven at 105°C for 17hrs [18]. The moisture content of seeds at the time of sowing was 5.22 per cent ( $\pm 1.04$ ). To study the effect of seed orientation during sowing on germination and subsequent seedling growth, de-winged seeds were sown in three different orientations *viz.*, vertical, horizontal and inverted. In vertical position, the seeds were placed in the germination medium with the wing side of the seed pointing upwards, in inverted position the wing side was kept pointing downward; and in horizontal position the seeds were placed flattened on the soil. Four replicates of 50, de-winged seeds each were sown in plastic trays containing river sand in a Completely Randomized Design (CRD). Similarly, to study the effect of different germination medium on seed germination and seedling growth, three media (soil, sand and vermiculite) were used. Four replicates of 50, de-winged seeds each were sown in plastic trays following CRD. Watering was done twice a day and daily counts were recorded for the germinating seeds. At the end of the germination test (i.e. after 45 days), ungerminated seeds were evaluated as fresh ungerminated and dead seeds, using the cutting test method [19]. After 45 days of germination, seedling parameters such as shoot length, root

length, collar diameter and number of leaves were measured. Four replicates of five seedlings each were randomly selected and measured. Vigour Index was determined according to Abdul-Baki and Anderson [20].

$$\text{Vigour Index} = \frac{\text{Mean germination per cent} \times \text{Mean seedling height}}{\text{Mean seedling height}}$$

#### *Effect of different containers on seedling growth under nursery conditions*

The seedlings were transplanted into single celled root trainers (of three different capacities -90 cc, 145 cc and 310 cc) and polybags of size 22.5 cm x 17.5 cm (1400 cc) using potting mixture consisting of soil, sand and compost in 3:1:1 ratio. The growth of the seedlings was measured for four months at monthly intervals. Parameters such as shoot length, root length, fresh and dry weight of shoot and root were recorded. Observations on insect/pest damage were recorded on nursery seedlings. The damage intensity by pest was recorded based on visual scoring as severe, moderate, and minor. The data were subjected to statistical analysis after appropriate transformations.

## RESULTS

#### *Effect of seed orientation on germination and seedling growth*

The positioning of seeds (i.e. orientation of seeds) had significant ( $p = 0.05$ ) effect on both, total germination percentage, and rate of germination. Earliest germination was noticed in horizontal position (13 DAS) and little later in vertical (14 DAS) and inverted (19 DAS) positions.

The results of ANOVA showed significant differences between different seed orientations ( $p = 0.05$ ) in all the characters studied except the number of leaves (Table 1). Horizontal and vertical sowings have given better results, and differed significantly from the inverted sowing. Both the cumulative germination and survival percentages were higher in horizontal sowing (both 92%) than in vertical and inverted sowings (87% and 82%; 11% and 11%, respectively). While performing the cutting test it was observed that among the un-germinated seeds, 6 per cent seeds

were decayed and 2 per cent were abnormal seedlings in horizontal position; 10 per cent decayed seeds and 3 per cent abnormal seedlings in vertical sowing and 83 per cent fresh seeds and 6 per cent abnormal seedlings in inverted sowing. Seeds sown in horizontal position had the shortest germination period (13-23 days) followed by vertical sowing (14-37 days). Seeds sown in inverted position took longest germination period (19-42 days).

Similarly, orientation of seeds affected the rate of seedling growth also (Fig. 1). Seeds sown in horizontal position had a mean seedling growth of 19.64 cm followed by vertical (18.54 cm) and inverted (17.64 cm) positions.

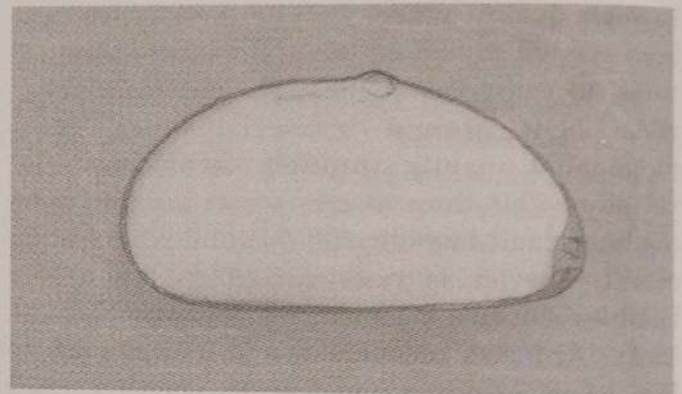


Fig. 1. Effect of seed orientation on seedling growth of *S. macrophylla* (45 days old). (a) Vertical, (b) Inverted and (c) Horizontal

#### *Effect of media on seed germination and seedling growth*

The results of the tests to observe the effect of media on seed germination and seedling parameters are presented in Figure 3 and Table 2, respectively. Differences in the media did not influence seed germination and the subsequent seedling growth, statistically. Obviously, however, there is a difference between them. In fact, both the cumulative germination percentage (98%) and the rate of germination were higher in the sand medium than in soil (95%) or vermiculite (93%) media. About 50 per cent germination was attained after 14, 16 and 19 days of sowing in sand, soil and vermiculite, respectively.

Results of ANOVA showed that there was no significant difference between different media on the various characters studied except the root

Table 1. Effect of seed orientation at the time of sowing on seed germination and seedling growth in *S. macrophylla*

Orientation	Germination percentage	Shoot length(cm)	No. of leaves	Collar diameter(cm)	Root length(cm)	Vigour index
Vertical	87 (± 008)	18.54 (± 1.44)	3.89 (± 0.03)	0.26 (± 0.03)	8.65 (± 1.30)	2365.53
Inverted	11 (± 006)	17.64 (± 1.32)	3.58 (± 0.52)	0.26 (± 0.03)	7.54 (± 0.87)	276.98
Horizontal	92 (± 009)	19.64 (± 1.82)	3.60 (± 0.52)	0.23 (± 0.01)	9.49 (± 0.78)	2679.96
EMS	0.0059	0.0019	0.0051	0.0010	0.0012	
LSD	0.0094	0.0030	0.0082	0.0016	0.0019	
P value	0.0000	0.0225	0.2573	0.0013	0.0000	

\*Retransformed mean values are given; Figures in parenthesis indicate standard deviation.

length (Table 2). Earliest germination was observed in both the sand and soil media on the 12<sup>th</sup> day of sowing. In vermiculite, however, seed germination commenced on the 15<sup>th</sup> day of sowing and culminated on the 29<sup>th</sup> day. Again, sand medium took only 19 days to complete the whole germination process while soil medium took 22 days.

#### Standardization of containers on growth performance under nursery conditions

The growth of seedlings at different ages is given in Figures 4 to 7. Although seedlings in polythene bags were superior in terms of height and biomass production than in root trainer, root trainer seedlings also attained plantable standards in three months.

## DISCUSSION

#### Effect of seed orientation on germination and seedling growth

Results of the present study showed that orientation of seed in the seed-bed had affected both the cumulative germination percentage and the length of the germination period of *S. macrophylla* seeds. The seeds sown in the horizontal position gave 92 per cent germination and had the shortest germination period (13 to 23 days), followed by those in the vertical (87%) and inverted (11%) positions, which took 14 to 37 and 19 to 29 days, respectively.

Previous studies on seed orientation of mahogany at the time of sowing gave contradictory results. Several authors have reported that vertical sowing position gave maximum germination in contrast to any other sowing positions [11-14]. On the contrary, Ponce [15] obtained better results in inverted position sowing. Reports have also indicated that seeds sown horizontally had higher germination percentage than seeds sown vertically [8]. However, workers like, Busby [16], Mondala [17] and Mayhew and Newton [8] reported that the orientation of seed had no effect on germination. On the contrary, seed orientation has significant effect on seed germination of *Swietenia macrophylla* as shown by present study results (Fig. 1 and Table 1).

Seed orientation had significant effect on germination in other species like some cereals [21]; *Pinus roxburghii* [3]; *Shorea robusta* [4]; *Derris indica* [5]; *Quercus leucotrichophora* [22] and *Tectona grandis* [6]. According to Mahgoub [7], the germination parameters related to orientation during sowing depended on germination type, seed size and seed shape. In her studies too, highest germination percentage was obtained when sown in horizontal position and vertical sowing with radicle end down was inferior to a position with the embryo facing upwards. In the case of *Quercus leucotrichophora* also, Lal and Karnataka [22] have obtained better results in

Table 2. Effect of different media on seed germination and seedling growth in *S. macrophylla*

Orientation	Germination percentage	Shoot length (cm)	No. of leaves	Collar diameter(cm)	Root length (cm)	Vigour index
Sand	98 (± 0 23)	19.35 (±2.10)	4.74 (± 0.72)	0.24 (± 0.02)	11.44 (±1.50)	3017.42
Soil	95 (± 0 00)	19.35 (±2.15)	4.49 (± 0.83)	0.23 (± 0.03)	10.23 (± 1.21)	2810.10
Vermiculite	93 (± 0 08)	17.68 (±2.57)	4.20 (± 0.70)	0.25 (± 0.03)	11.59 (±1.89)	2722.11
EMS	0.0193	0.0043	0.0052	0.0042	0.0046	
LSD	0.0309	0.0069	0.0083	0.0609	0.0073	
P value	0.1926	0.1344	0.0914	0.5167	0.0547	

\*Retransformed mean values are given; Figures in parenthesis indicate standard deviation.

terms of total germination, plant percentages and germination period when seeds were sown horizontally than in upward or downward positions. On the contrary, Swaminathan *et al.*, [5] in *Derris indica* reported that vertical sowing with the radicle end down was superior to any other positioning during sowing.

One of the reasons for poor germination when seeds were sown in inverted positions is that the radicle as well as hypocotyl end will have to make a curvature of 90° for normal seedling establishment. The proper directional growth of plumule and radicle would therefore require additional hormones as well as extra energy. These factors may be limiting in seedling emergence and survival [4].

#### Effect of media on germination and seedling growth

Germination medium has considerable influence on seed germination. Coarse sand, loamy and coarse textured soils which hold most of the available water, have been found to facilitate germination of seeds that require humid condition to germinate [6]. Of the different media like sand, soil and vermiculite studied, germination and number of normal plantable seedlings were higher in river sand medium than in soil and vermiculite media. Owing to a high fatty acid content, mahogany seed require more oxygen during germination than starchy seeds and

therefore germination may be faster in well-aerated germination medium. This might be the reason for early seedling emergence in sand followed by soil, perhaps both the media are well aerated. The ability of seeds of *S. macrophylla* to germinate better in sandy soils, which have low water-retaining capacity, shows that the seeds do need high humid conditions to germinate. Again, the seedling emergence in vermiculite was delayed as the vermiculite formed a crust above the seeds and therefore, it was difficult for the plumule to penetrate through the medium. Mayhew and Newton [8] while studying seed germination of the same species observed that the formation of a crust above the seeds caused the shoot to coil under the surface which affected the early emergence of seedlings.

The development of mahogany seedlings has some correlation with seed orientation and soil types which results a wide variation in its germination period. The differences in germination period of *Swietenia macrophylla* obtained by different workers earlier might be due to various factors such as moisture content and age of seeds, depth and orientation during sowing, the kind of media used and the hazardous conditions to which the seeds were exposed. Our experience shows that the germination period varies for fresh and stored seeds, primarily depending upon the moisture content and age of the seeds. Usually, fully ripe

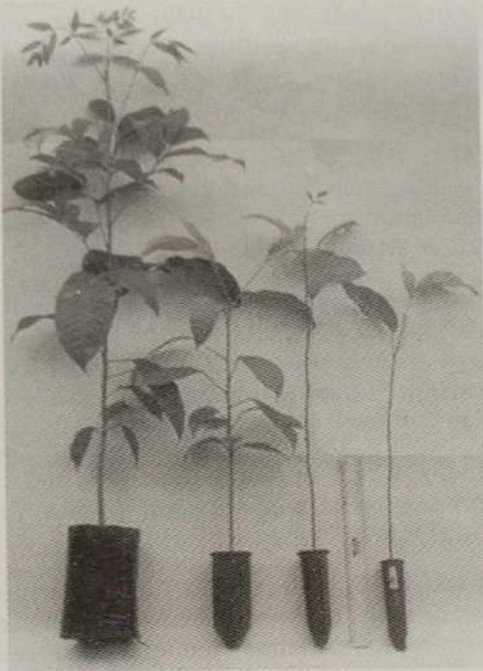


Fig. 2. L.S. of *S. macrophylla* seed (Seed coat removed)

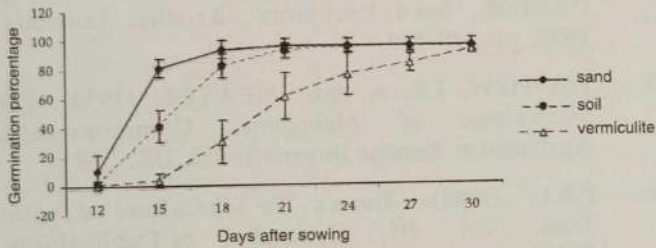


Fig. 3. Effect of media on seed germination of *S. macrophylla*

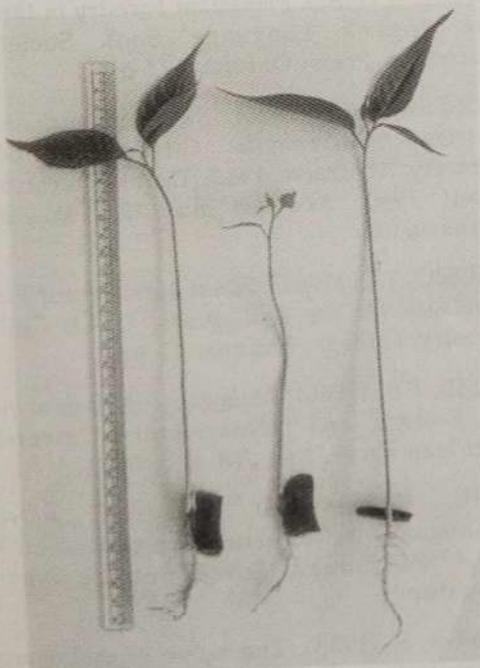


Fig. 4. Six months old seedlings of *S. macrophylla* in 1400 cc (22.5 x 17.5 cm) polybag, 310 cc, 145 cc and 90 cc root trainers

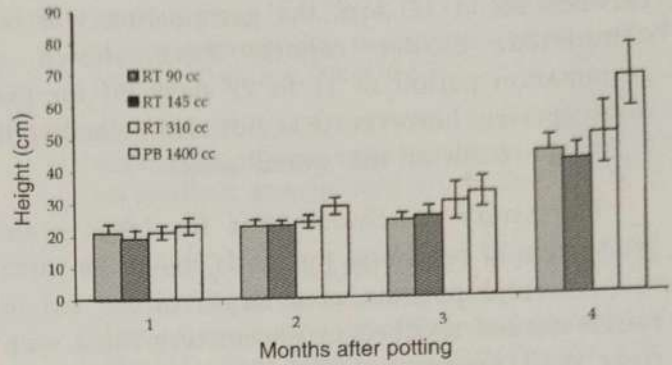


Fig. 5. Height growth of *S. macrophylla* seedlings in different containers

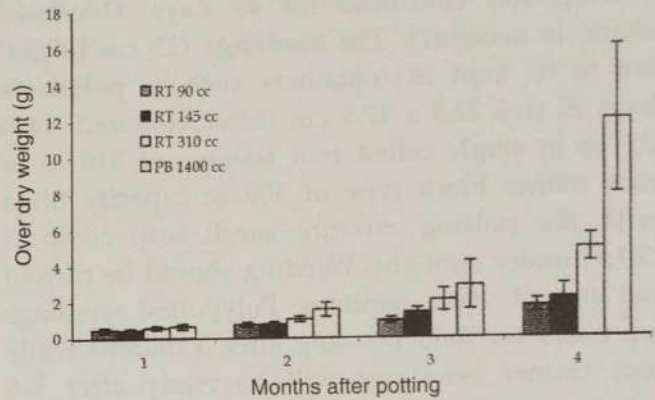


Fig. 6. Shoot biomass of *S. macrophylla* seedlings in different containers

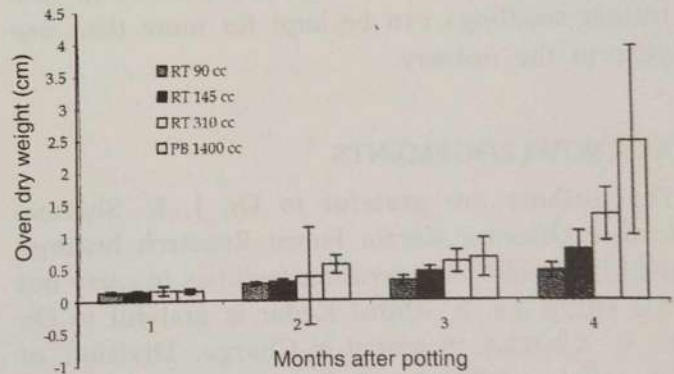


Fig. 7. Root biomass of *S. macrophylla* seedlings in different containers

fresh seeds germinate on 22<sup>nd</sup> day of sowing and complete the germination before 45<sup>th</sup> day after sowing whereas seeds stored for a few days soon after collection germinate a little early. Again, artificially aged seeds take 14 days to commence germination and completes the same on 23 days after sowing while naturally aged seeds germinate 18 to 19 days after sowing and

between 35 to 42 days the germination will be completed. Earlier reports have shown a germination period of 11 to 97 days [9] for the same species, however, it is not clear whether it is for the fresh or the stored seeds.

The study concludes that for large scale production of seedlings, the seeds should be sown in horizontal position at a depth of 2-3 cm in raised shaded seedbed in the nursery filled with river sand/garden soil. Regular, twice in a day, watering (morning and evening) is recommended. Germination commences after 19 to 21 days of sowing and continues for 45 days. Overhead shade is necessary. The seedlings (25 cm height) are to be kept in containers such as polythene bags of size 22.5 x 17.5 cm (black coloured, 1400 cc) or in single celled root trainers of 310 cc or root trainer block type of 300 cc capacity filled with the potting mixture sand: soil: compost (3:1:1) under sunlight. Weeding should be carried out as and when required. Polypotted seedlings are ready for field planting after 3 months while root trainer seedlings will be ready after 5-6 months. However, the polypotted seedlings can be kept for up to 5 months in the nursery since root coiling occurs afterwards where as in root trainer seedlings can be kept for more than one year in the nursery.

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