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Propagation Protocols for Enhancing Conservation and Utilization of *Melia dubia* Cav.

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ABSTRACT

India's annual imports of logs and wood products have increased from $500 million to $2.7 billion over the past decade. Many tree species have been taken up for the promotion of tree cultivation outside the forest areas; one of them is *Melia dubia* Cav. (Meliaceae). It is a multipurpose tree species, finding use as a raw material for plywood, fodder for livestock, and a secondary timber. Large-scale planting is hampered by poor seed (less than 10 %) germination despite producing abundant quantities of fruits every year; lack of package of practices thereby making planting stock unavailable. A research study was carried out at the Institute of Forest Genetics and Tree Breeding in Coimbatore, India to investigate seed germination and rooting of cuttings. Seeds were subjected to different pretreatments against control. Seeds stored in polybags under ambient conditions for over a year gave the highest germination (94.01 per cent). Juvenile stem cuttings (coppice), branchlets and mature branches of *M. dubia* were tried for rooting / sprouting. Coppice responded well to 1000 – 2000 mg/l IBA (liquid formulation). Sand was identified as the best rooting media for the multiplication of coppice. The stumps produced good coppice when cut at 120 cm above ground level with high survival percentage (60%) and increased sprout production. The size of the cutting and season of rooting plays a major role in the rooting of cuttings. Success in nursery production through vegetative production will open an opportunity to successful large scale plantations of *M. dubia.*

Key Words:

Coppice, Malabar neem, Plywood, Seed germination, Rooting, Vegetative propagation.

INTRODUCTION

India is one of the largest consumers of wood in Southeast Asia (NCCF 2017). The largest importer of wood and wood products (FAO 2011), its imports are mainly from Malaysia, Myanmar, Indonesia, Nigeria, Ivory Coast, Ghana, Togo, Gabon, Brazil, Panama, Costa Rica, Ecuador and New Zealand (Anon 2016). The current supply of raw materials for wood-based industries is far behind the demand. Further, with increase in population, demand for wood by various sectors is also increasing. To meet this demand, industries are expanding their plantation programme. Industries also look towards agroforestry and farm forestry sources to meet the demand. Presently majority of harvested wood comes from "Trees Outside of Forests (TOF) such as tree plantations, farms, and private lands. The growing stock of trees outside forests in India is estimated at about 5.8 billion cu. m (FSI 2017). Within India the area under plantations is increasing.

With reduced availability of conventional timbers, there is a shift towards utilising alternative species such as poplar, eucalyptus, casuarinas, Melia dubia and acacias to meet the demand by local wood based industries (ITTO 2014). *Melia dubia* has caught the attention of the farmers due to its fast growth, multiple utility and the rapid economic returns. It is most favoured for plywood and is a species with high carbon assimilation potential. *M. dubia* is also valued for its high-quality termite and fungus resistant timber (Suprapti et al., 2004). It bears a clean cylindrical bole of about 20 -40 ft. The species is native to southern Asia, and is presently widely cultivated in South Africa, Middle East, America (Bermuda, Brazil and Argentina), Australia, SE Asia-Pacific islands, and southern Europe (Luna 1996; Ram et al. 2012).

The timber finds application in furniture, agricultural implements and house construction (Mandang and Artistien 2003). Its branches find good use as fuel wood and leaves as fodder. In Sri Lanka, it is widely distributed in the intermediate and wet zones and used for out-riggers of boats (FAO 1990). It is also adopted for afforestation and land rehabilitation (Langenberger et al. 2005).

The species is currently being promoted as a source of industrial pulpwood through contract farming. Trees with girth 20 inches or below fetch Rs 2,000 ($40 USD) per tonne for the match industry; the market rate is Rs 7,500 ($120 USD) per tonne for the ply industry. With the girth crossing the 50 inch mark, the wood is sold in volume, where one cu. ft fetches Rs. 750 ($10 USD). A tree attains a volume of 15 cu. ft in five years when grown under favourable conditions (Warrier 2011).

M. dubia is being widely introduced in all parts of the country. But, large-scale planting is hampered by poor seed germination (less than 10 %), despite producing abundant quantities of fruits every year (Tilakaratna 1991; Nasayao et al. 1993; Nair et al. 2002,;Nair et al. 2005). As a result, planting stock is not available to the farmers and other planting agencies. Researchers state that poor germination rates are due to the hard stony coat (Nair et al. 2005; Manjunatha 2007; Anand et al. 2012).

An idea of the available variation in fruit and seed characteristics and germination behavior of a species is helpful in selecting the best available geographic source of seeds (Kertadikara and Prat 1995). Variation in weight and dimensions of seeds may result from the diversity in edapho-climatic conditions of the habitats combined with genetic variability (Friis 1992). With heavy demand for the species, there is a need to explore other methods of regeneration to mass propagate the species. Land availability being a limiting factor, clonal forestry is a good option in commercial forestry. Gains made from selections within existing natural variations enables maintaining genetic superiority of trees. The developed clones aim at higher productivity or adaptability to specific sites. Information on production of clones from coppice shoots is lacking, though the species is a good coppicer. The present study tries to understand reasons behind poor germination, techniques to enhance the same, and the possibilities of using coppice cuttings for macro propagation.

MATERIALS AND METHODS

The present study was carried out during 2010-2015 in the Institute of Forest Genetics and Tree Breeding, Coimbatore, India (11.0104° N, 76.9499° E with an altitude of 411 MSL). Ripe fruits were collected from selected *Melia dubia* trees from different locations (Table 1) and identities maintained.

Variability in fruit and stone parameters

The fruits were wiped well to remove surface dust and 100 fruit weight determined (5 replications) using an electronic balance. Five replicated samples, each consisting of 25 fruits per lot, were randomly sampled and subjected to image analysis using QWin 500 software (Leica Microsystems GmbH, Germany) with the help of a CCD (charge-coupled device) camera. Physical characteristics - length (cm), width (cm), roundness, aspect ratio (ratio of length to width of the stone) were measured. The fruits were depulped, shade dried and 100 stone weight (5 replications) was determined. Stone morphology was also recorded as described above. The stones were later subjected to germination in raised beds with the growing media of Soil: Sand: FYM (3:1:1). Percentage plant production and germination energy (GE) were determined. Percentage plant production is the proportion of total number of seedlings to that of sown stones. GE (in percentage), is computed as the proportion of germinant after 60 days to that of total germinated stones after 120 days. Growth performance of seedlings in terms of seedling height (mm), collar

Table 1: Details of location of trees, fruit and stone parameters of *Melia dubia*

Place	Lat	Long	Fruit Area (cm^2)	Fruit Length (cm)	Fruit Width (cm)	Fruit Round -ness	Fruit Aspect ratio	Stone Area (cm^2)	Stone Length (cm)	Stone Width (cm)	Stone Round-ness	Stone Aspect ratio
Ardhanalli	11.53	76.57	3.90	2.61	2.02	1.74	1.30	2.17	2.16	1.40	1.60	1.56
Basapura	11.50	76.58	4.78	2.89	2.20	1.55	1.32	1.78	2.00	1.28	1.57	1.57
Bedamula	11.53	76.58	4.52	3.00	2.02	1.69	1.49	2.19	2.21	1.38	1.63	1.61
Chamrajnagar	11.54	76.56	3.93	2.73	1.92	1.41	1.43	2.38	2.48	1.38	1.59	1.81
Chikkahole I	11.50	76.59	5.02	3.09	2.19	1.55	1.42	1.88	2.15	1.28	1.72	1.69
Chikkahole II	11.51	76.59	4.70	2.96	2.11	1.60	1.40	1.98	2.15	1.33	1.50	1.62
Chikkali	11.44	77.01	5.07	2.99	2.30	1.48	1.26	2.90	2.94	1.50	1.62	1.97
Dhulsur	12.28	77.49	4.35	2.63	2.20	1.76	1.20	1.92	2.09	1.32	2.12	1.59
Dinnur	12.52	77.73	4.59	2.83	2.15	1.77	1.32	2.37	2.31	1.41	2.00	1.65
Doddapuram	11.36	76.59	5.35	3.05	2.33	2.18	1.32	1.94	2.26	1.26	1.54	1.81
Ecoawareness	12.29	77.50	5.49	2.99	2.43	1.53	1.24	2.03	2.16	1.32	2.04	1.64
Ellakattai	11.48	76.59	4.19	2.79	2.01	1.62	1.39	2.81	2.68	1.48	1.97	1.81
Gowthalam I	12.33	77.49	5.52	3.18	2.37	1.48	1.33	1.83	2.12	1.21	1.97	1.74
Gowthalam II	12.32	77.48	5.61	3.10	2.36	1.49	1.31	1.95	2.05	1.31	1.55	1.57
Kodipuram I	11.37	77.00	4.47	2.61	2.27	2.00	1.16	1.90	2.16	1.26	1.39	1.72
Kodipuram II	11.38	77.00	5.25	2.91	2.37	1.69	1.23	2.23	2.46	1.31	2.06	1.88
Maharajapuram	11.45	77.01	4.66	2.84	2.22	1.80	1.28	2.39	2.48	1.42	1.59	1.77
Nagondapalli I	12.39	77.47	5.43	3.02	2.36	1.70	1.28	2.14	2.29	1.32	1.88	1.74
Nagondapalli II	12.40	77.47	3.81	2.72	1.86	1.26	1.47	1.85	2.03	1.23	1.81	1.66
Saamayeri	12.23	77.51	4.42	2.92	2.01	1.72	1.49	2.02	2.19	1.29	1.37	1.71
Santhanapalli	12.28	77.50	5.03	2.95	2.25	1.69	1.31	1.98	2.19	1.26	1.96	1.74
Thalamalai I	11.36	77.00	4.19	2.71	2.06	1.49	1.32	2.02	2.13	1.25	1.60	1.71
Thalamalai II	11.37	77.00	6.59	3.48	2.46	1.82	1.43	2.48	2.66	1.37	1.56	1.94
Thalavady	11.47	77.00	4.74	2.77	2.26	1.65	1.23	2.22	2.33	1.36	1.45	1.72
Unsetti	12.25	77.50	5.32	2.99	2.31	1.42	1.30	2.03	2.18	1.28	1.95	1.70
Maximum			6.59	3.48	2.46	2.18	1.49	2.90	2.94	1.50	2.12	1.97
Minimum			3.81	2.61	1.86	1.26	1.16	1.78	2.00	1.21	1.37	1.56
Average			4.84*	2.91*	2.20*	1.64*	1.33*	2.14*	2.27*	1.33*	1.72	1.72
CV (%)			13.39	6.79	7.42	11.85	6.77	13.50	10.00	5.62	13.35	6.40

Values are means of five replications (25 fruits / stones each). * Significant at $p<0.05$

diameter (mm) and number of leaves was recorded.

Germination studies

The fruits were categorized into small, medium and large based on the fruit parameters. 100 fruits were selected in each category. Following depulping, the stones were cut open using secateurs. The number of locules present and their filling was recorded. When there was no seed found in a locule, it was treated as empty locule. The seeds enclosed within the stones were tested for viability using tetrazolium staining.

Assessment of seed germination following different pre-sowing treatments: Three lots identified as low (< 10 per cent), medium (10 – 40 per cent) and high (>50 per cent) germination were selected from earlier experiments. The stones were subjected to different treatments to enhance germination. A Randomized Complete Block Design (RCBD) was adopted for the study. There were eight treatments including control and 4 replications for each treatment. T1: Control; T2: Water soaking (24 hrs); T3: Cow dung slurry (5 days); T3: Cow dung (10 days); T4: Gibberellic acid (100 mg/l, 24 hrs); T5: Treatment with conc. H2SO4 (10 mins); T6: Treatment with conc. H2SO4 (10 mins) + Gibberlic acid (100 mg/l, 24 hrs); T7: Alternate soaking and drying (15 days); T8: One year old seeds stored in ambient conditions in polybags.

Stones were sown in germination beds. The beds were watered every morning. Seedling emergence was counted for 120 days on a daily basis.

Vegetative Propagation Studies

Coppicing ability of stumps: Rooting of stem cuttings is the most widely practised method of vegetative propagation in tree species. Since Melia was identified as a good coppicer, attempts were made to induce juvenility in mature trees through generation of coppice shoots. Experiments were undertaken in three year old trees (having a girth of ~80 cm) raised at Institute of Forest Genetics and Tree Breeding, Coimbatore, India.

Trees were coppiced at various heights (30 cm, 60 cm, 90 cm and 120 cm) from the ground level. A slanting cut without splitting the wood was given to the trees during coppicing to avoid water stagnation on the cut end and copper oxychloride paste was applied to the cut surface immediately after the cut to avoid fungal infection. Treatments including mulching, applications of fertilizer (30g urea per stump) and growth regulator (formulation containing Triacontanol) were given to all the coppiced trees. The experiment was laid out in Randomized Complete Block Design with 4 replications and 3 trees per replication. All the stumps were watered daily to maintain adequate moisture.

Shoots derived from the coppice growth were treated with 0. 1 per cent Bavistin (a broad spectrum systemic fungicide containing 50% WP carbendazim) for 15 minutes to avoid fungal attack and dip smeared in rooting media (4000 mg / l Indole - 3 - Butyric Acid). Subsequently, the treated cuttings were placed in root trainers (150 cc) filled with different media -namely moistened vermiculite grade IV, coir pith, sand and soil placed in the polytunnel. The polytunnel unit was approximately 180 cm long and 90 cm wide with sloping roof for draining the condensation water on the inner side. The roof and sides of the structure were covered with 400 gauge polythene sheet. The polytunnel was kept on a surface filled with sand to a depth of one foot. Prior to placing the cuttings inside the tunnel, the sandy area was well watered without flooding. This provided a warm-humid (temperature varied approximately from 38 - 42oC with a high humidity range of 80-90 per cent) environment, very conducive for rooting process. Cuttings were placed in the tunnel with the sides of the tunnel tightly tucked in sand. The tunnel was opened after 25 days when rooting had occurred. Data on number of coppice shoots produced, and rooting percentage were recorded.

Standardization of hormones, season and rooting media: Different concentrations of hormones (IAA, IBA and NAA) were tried for rooting of coppice shoot cuttings and branch cuttings.

Impact of season on rooting: The rooting experiments of coppice shoot cuttings as well as branch cuttings were conducted in different seasons to find the effect of season on rooting.

Data analysis

Data was subjected to analysis of variance (ANOVA). The level of significance used in F test was P= 0.05. The co-efficient of variation was calculated for the parameters. All the analyses were performed using SPSS 20. The germination percentage values were subjected to angular transformation before statistical analysis.

RESULTS AND DISCUSSION

Variability in fruit and stone parameters

The success of any crop improvement programme depends on the extent of genetic variability in the base population. Understanding intra and inter population variation for reproductive traits would be essential for popularization of species. This also helps in further selection and improvement of species for commercial traits to obtain higher yield. Fruit and stone characters in *M. dubia* were assessed to understand the extent of variation existing, which is reported to influence seed germination (Table 1). Fruit area varied from a minimum of 3.81 cm^2 to a maximum of 6.59 cm^2, length from 2.61 to 3.48 cm; fruit width varied from 1.86 to 2.46 cm. The fruit roundness and aspect ratio had means values of 1.64 and 1.33 respectively. Stone area varied from a minimum of 1.78 cm^2 to a maximum of 2.9 cm^2, length from 2.0 to 2.94 cm; stone width varied from 1.21 to 1.51 cm. The fruit roundness and aspect ratio had means values of 1.72. Significant variation was seen in fruit and seed parameters except seed roundness and seed aspect ratio. The co-efficient of variation was observed to be low in all the parameters studied. Morphological variability in fruits and seeds enables a better understanding of the biodiversity in natural populations and supports genetic, taxonomic and biodiversity studies. Variability within a species reflects local adaptation, phenotypic plasticity, and gene flow (Hovick et al. 2018).

Morphological variations in fruit/pod and seed characteristics among the natural population are useful in selection programme for genetic improvement of forest species (Bahadur and Hooda 1995; Kaushik et al. 2007). For screening the naturally available genetic variations to select the best planting material for attaining higher productivity, source variation tests are very much necessary (Bhat and Chauhan 2002).

Germination studies

Fruit morphology particularly size, helps to understand the mechanisms of species dynamics in plant communities (Janyszek et al. 2008). 100 fruits were selected in the categories small, medium and large based on the fruit parameters. The number of locules and filling varied with fruit size (Fig 1and 2). Small fruits showed 90 per cent emptiness. The remaining 10 percent recorded only one seed. Medium fruits ranged from empty to two seeds, with one seeded fruits occupying 80 per cent. Large fruits showed highest number of filled locules (4 seeded); in some cases it reached upto six, with a record of atleast two seeds per fruit. Large fruits did not record emptiness.

Hundred fruit weight varied from 380 g to 1 kg with an average of 730g. The 100 stone weight ranged from 110g to 280g with an average value of 190g. The coefficient of variation of 100stone weight was comparatively lesser than the fruit weight though both recorded high CV.

Fig 1. Filling pattern of locules in *Melia dubia*

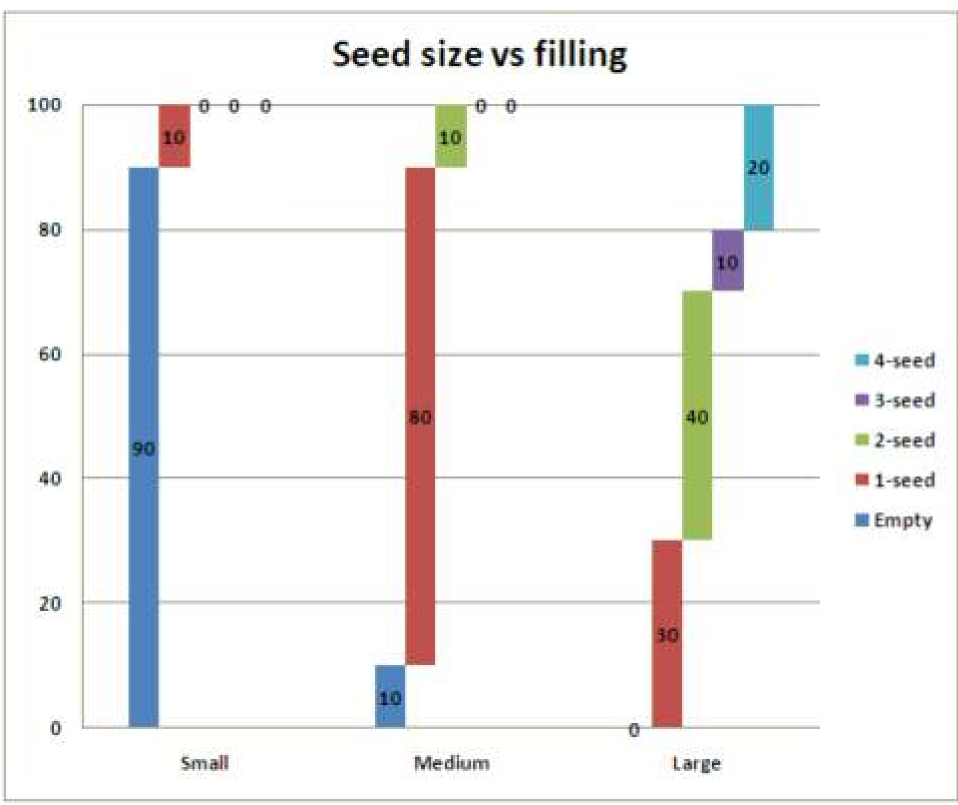

Fig 2. This figure gives a comparative assessment of the filling of locules within *Melia dubia* with respect to the size of the fruits. (n=100)

The fruit to stone weight ratio, which suggests the proportion of pulp within the fruit, ranged between 2.43 and 5.5 with an average of almost 4. The average number of locules were 3.0 ranging between 1.6 and 5 while the seed filling ranged between 1.4 and 4 with an average of 1 (Table 2). Germination showed very high variability, the CV almost 75 percent. A corresponding variation in the germination energy was observed. Cut tests revealed that the seeds enclosed within the stones were viable. Greater seed dimensions in a given provenance have been attributed to better seed filling due to favorable habitats (Bahar 2007). Jakobsson and Eriksson (2000) reported that large seeds are prevalent closed and shady environments while small fruits are observed in open and disturbed environments. But in the case of Melia, it could be inferred that fruit and stone size, and filling did not play a role in deciding the germination ability of the species, as no definite trend could be observed with respect to these parameters.

Growth performance assessed in terms of the seedling length (mm), collar diameter (mm) and number of leaves per plant produced is presented as box plots (Figs 3-5). The vigorous growth of the seedlings and subsequent survival in the field depends mainly on the quality of seeds (Abideen et al. 1993). Schmidt, 2000 states that seed germination and seedling vigour is affected by seed size and other factors like dormancy, moisture, etc. Gunaga (2011) reports that bigger sized seeds of C. inophyllum produced quick, uniform and maximum germination as well as vigorous seedling and higher dry biomass as compared to those of medium and small sized seeds. Seeds sources Thalavady, Dinnur and Nagondapally II showed maximum height while the least was recorded by Unsetti. Outliers in the data were observed in seedlings obtained from Chikkali, Doddapuram, and Gowthalam II. Nine seed sources produced seedlings above the average mean of the accessions (43.59 mm). The variability within and between sources was also very high. The CV recorded was 31.7 per cent.

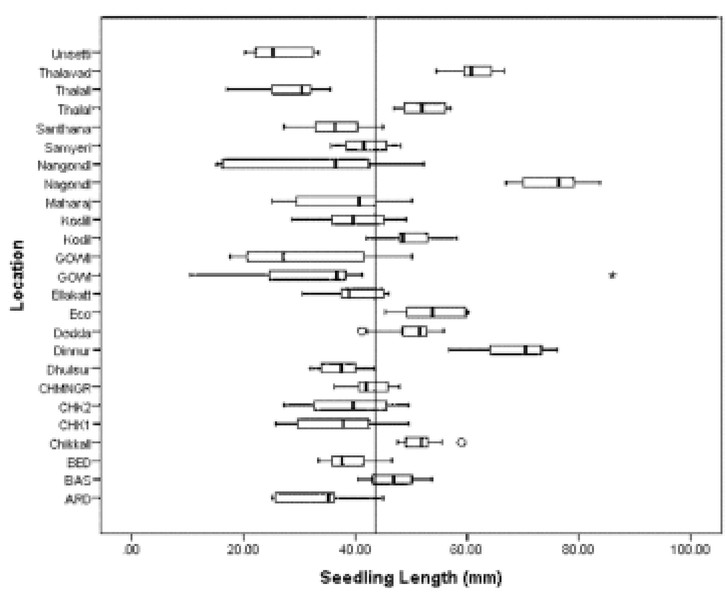

Fig 3. Box plot representation of the height of seedlings of Melia dubia raised from seeds collected from different locations. The box plot displays the 10th, 25th, 50th, 75th, and 90th percentiles.

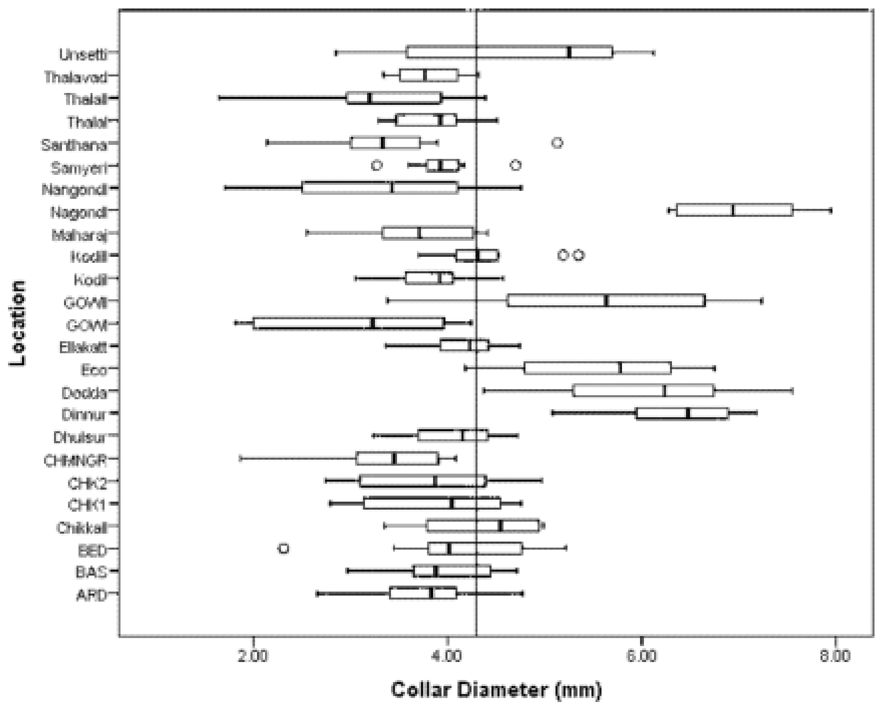

Fig 4. Box plot representation of the collar diameter of seedlings of *Melia dubia* raised from seeds collected from different locations. The box plot displays the 10th, 25th, 50th, 75th, and 90th percentiles.

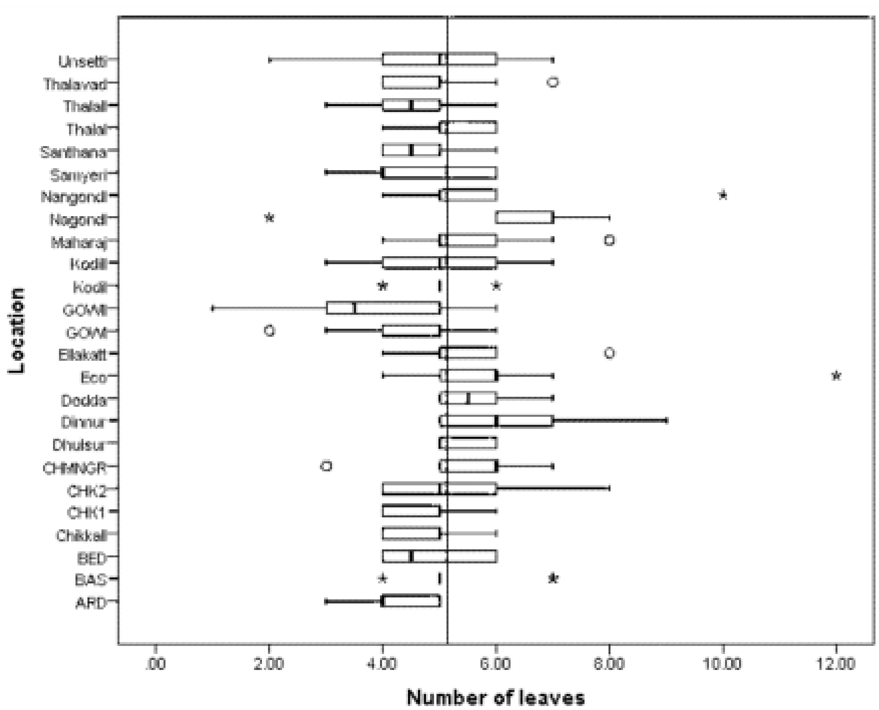

Fig 5. Box plot representation of the number of leaves in seedlings of *Melia dubia* raised from seeds collected from different locations. The box plot displays the 10th, 25th, 50th, 75th, and 90th percentiles.

Table 2. Fruit and Stone weight, Fruit to Seed ratio, locule filling, plant production and germination energy (GE) of *Melia dubia* obtained from different locations.

LOCATIONS	100 Fruit weight (kg)	100 Stone Weight (kg)	Fruit to Seed ratio	Number of Locules	Number of filled locules	Plant %	GE
Ardhanalli	0.568	0.182	3.12	3.4	3.4	23	0.31
Basapura	0.729	0.174	4.19	3.6	3.6	62	0.61
Bedamula	0.608	0.179	3.40	2.4	2.4	37	0.14
Chamrajnagar	0.458	0.153	2.99	2.6	2.6	44	0.47
Chikkahole I	0.788	0.222	3.55	2.2	2.2	70	0.48
Chikkahole II	0.740	0.195	3.79	2.2	2.2	20	0.28
Chikkali	0.778	0.199	3.91	2.8	2.8	120	1.78
Dhulsur	0.770	0.140	5.50	5.0	2.4	1	0.00
Dinnur	0.750	0.180	4.17	4.0	4.0	30	0.72
Doddapuram	0.789	0.189	4.17	4.0	1.4	7	0.18
Eco awareness	0.580	0.140	4.14	2.0	1.8	5	0.04
Ellakattai	0.630	0.158	3.99	2.0	2.0	33	0.43
Gowthalam I	0.660	0.210	3.14	2.4	2.4	57	0.37
Gowthalam II	0.380	0.110	3.45	2.2	1.8	26	0.40
Kodipuram I	0.841	0.189	4.45	2.0	2.0	72	0.44
Kodipuram II	0.806	0.161	5.01	2.8	2.8	85	0.57
Maharaja puram	0.729	0.186	3.92	2.2	2.2	11	0.40
Nagondapalli I	1.000	0.200	5.00	2.4	2.4	9	0.17
Nagondapalli II	0.840	0.220	3.82	2.6	2.6	15	0.33
Saamayeri	0.560	0.230	2.43	1.6	1.6	61	0.69
Santhanapalli	0.620	0.180	3.44	4.0	3.3	25	0.40
Thalamalai I	0.989	0.217	4.56	4.4	2.2	54	0.92
Thalamalai II	0.932	0.183	5.09	3.8	3.8	41	0.58
Thalavady	0.800	0.171	4.68	3.6	3.6	89	1.00
Unsetti	0.900	0.280	3.21	4.8	2.2	15	0.36
Maximum	1.00	0.28	5.50	5.00	4.00	120.00	1.78
Minimum	0.38	0.11	2.43	1.60	1.40	1.00	0.00
Average	0.73*	0.19*	3.97*	3.00*	2.55*	40.48*	0.48*
CV (%)	21.15	18.45	18.82	32.43	27.68	75.35	75.28

Values are means of five replications (25 fruits / stones each). * Significant at $p<0.05$

With respect to the collar diameter, the average of all the seedlings was 4.3 mm. The co-efficient of variation was 29 per cent. Only six seed sources, namely Unsetti, Gowthalam II, Ecoawareness, Doddapuram, Dinnur and Nagondapally I recorded values above the population mean. In the case of collar diameter, the numbers of outliers were higher. Santhanapalli, Samayeri, Kodipuram I and Bedamula were the seed sources which recorded outliers. Within variability was less in this case (Fig 4).

The population mean for number of leaves was 5.13 (Fig 5). Within population variability was observed to be low. However, large numbers of outliers were observed in this case. This could be due to the genotypic differences occurring between the seedlings.

Assessment of seed germination following different pre-sowing treatments: Stones categorized based on the germination were subjected to eight different treatments. The germination of Melia dubia varied from 6.90 to 94.01 % across the different categories. The order of decreasing germination was High > Medium > low. Low germination seeds recorded a range between 6.90 to 15.95%, while the medium category recorded a range 28.88 to 59.80 per cent.

Seed germination was enhanced in the high germination category, the percentage increasing from 50.82 to 94.01, almost twice the levels of the control (Table 3). Similar trend was observed in the medium and low germination categories. Seeds stored in ambient conditions in polybags for one year and then subjected to germination recorded the highest germination percentage in all the cases.

Table 3. Germination of *Melia dubia* as influenced by different presowing treatments.

Treatments	Small Fruits	Medium Fruits	Big Fruits
T1: Control	7.95	35.20	50.82
T2: Water soaking (24 hrs)	7.20	39.80	51.20
T3: Cow dung slurry (5 days)	7.74	29.52	54.32
T3: Cow dung (10 days)	7.08	28.88	62.44
T4: Gibberellic acid (GA - 100 mg/l, 24 hrs)	6.90	31.24	63.35
T5: Treatment with conc. H_2SO_4 (10 mins)	8.13	33.88	70.63
T6: Treatment with conc. H_2SO_4 (10 mins) + GA (100 mg/l, 24 hrs)	9.27	29.40	73.08
T7: Alternate soaking and drying (15 days)	7.47	35.20	81.97
T8: One year old seeds stored in ambient conditions in polybags	15.95	59.80	94.01
Maximum	15.95	59.80	94.01
Minimum	6.90	28.88	50.82
Average	8.63*	35.88*	66.87*
CV (%)	32.84	26.90	21.86

*Values are means of four replications. * Significant at $p<0.05$*

Comparing germination result of the three categories of drupes, it could be observed that combined dormancy such as embryo and chemical dormancy exists in Melia dubia. Drupes having the stony seed coat following alternate drying and wetting treatment (in high category), soaking for 24 hr in water (medium category) and acid scarification with GA treatment (in low category) also increased germination. This shows the presence of physical dormancy in the seed. Alternate drying and wetting treatment of drupes improved the imbibition of seeds inside fruit. Physical dormancy is the exclusion of water from the embryo via an impenetrable seed coat or fruit wall (Hartmann et al. 1997). Physical dormancy has been reported as an important dormancy mechanism affecting teak seed germination (Schmidt 2000). Similar to the drupes in Teak, Melia also exhibits physical dormancy. Morphological embryo dormancy involves a requirement of embryo maturation or after-ripening after dispersal. Low rates of germination in fresh seedlots compared to those which are one year old implies that embryo dormancy is present in Melia .

Vegetative Propagation Studies

Coppicing ability of the stumps: It was observed that stumps coppiced well when cut at

120 cm above ground level (Fig 6). 120 cm stumps gave the best survival percentage (60%) with the best coppice ability in terms of sprout number production (10). Though stumps of height 90 cm also produced sufficient coppice, the shoots did not survive. An increasing trend in coppice shoot induction was noticed with increase in length of the stump height. Another difference observed in the coppice shoots arising from stumps of varied heights was diameter of the sprouts. Sprouts with diameter 0.5 cm or less (pencil thickness) observed in stumps of height 60 cm and less showed poor rooting and survival ability (Fig 7). The rooting ability recorded was relatively low i.e. 16%, 18% and 11 % from 30, 60 and 90 cm stumps respectively.

Standardization of hormones, season and rooting media

The sprouts were collected and treated with different concentrations of hormone IBA (liquid and powder formulations) and tried for rooting. Pilot studies using IAA, IBA and NAA revealed that shoots responded well to IBA and hence the same was used throughout the experiments. Coppice shoot cuttings showed good rooting in sand (80). Adventitious rhizogenesis occurred within 5 to 10 days after planting. The next best medium was coir pith (60). Potting medium and vermiculite did dot facilitate rooting of the coppice shoots (Fig 8). Rooting of cuttings of Melia dubia taken in intervals of three months (coinciding with the leaf fall and flush in the species) during autumn, winter, spring and summer revealed that the coppice collected in March, when new flush of leaves appears was the best season for rooting. Shoots collected during September to December recorded poor rooting.

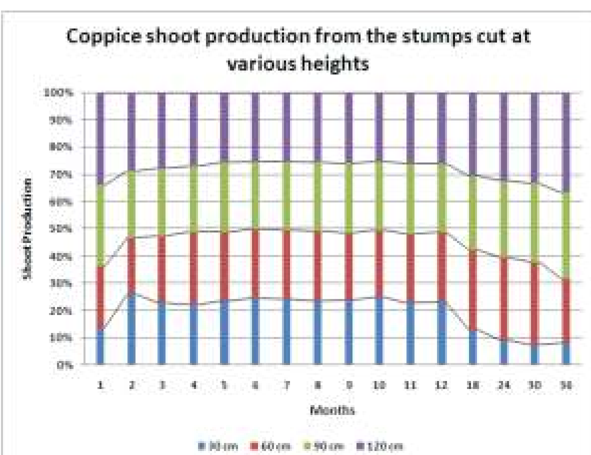

Fig. 6 Coppice shoot production from the stumps cut at various heights (30, 60, 90 and 120 cm)

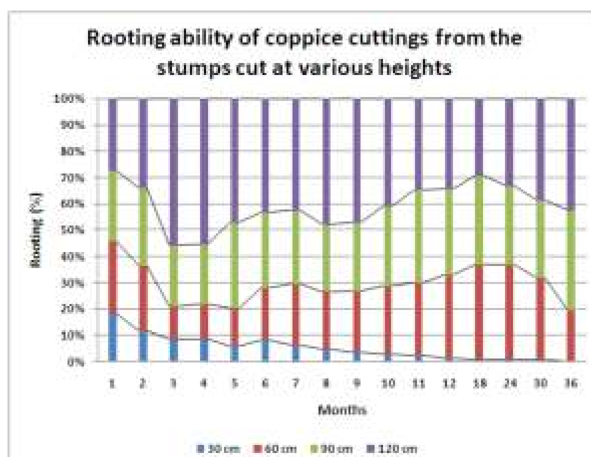

Fig. 7 Rooting ability of coppice cuttings from the stumps cut at various heights (30, 60, 90 and 120 cm)

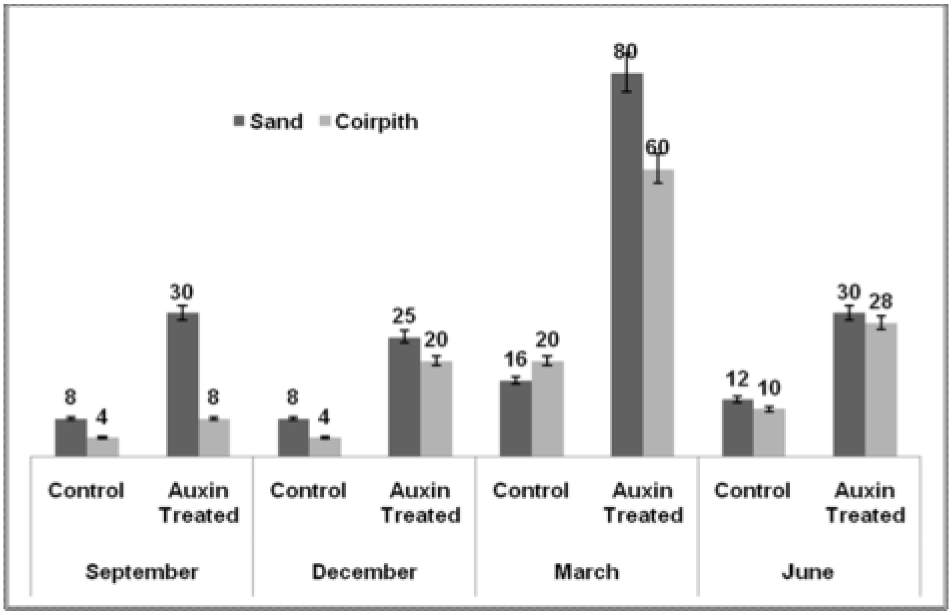

Fig. 8 Effect of season on the rooting ability of coppice shoots of *Melia dubia* in different media

There was significant variation in rooting percentage during different seasons in coppice shoot cuttings of Melia indicating that season has a major effect on rooting in the species, which is similar to the earlier findings (Bhatnagar and Joshi, 1978; Nautiyal et al. 1992; Palanisamy et al. 1995). Palanisamy and Pramod Kumar 1996 reported that in Neem significant adventitious formation occurs only in leaf fall season, whereas in other season the rooting was very poor. Similar results have been obtained in our experiments also indicating similar responses between species of the same family.

Cuttings taken during spring resulted in 80 % rooting, however, no rooting was found in cuttings taken in autumn and winter which developed new leaves within three weeks, but did not develop any further. A total of 90% of these cuttings dropped their leaves after six weeks and showed no signs of rooting. Cuttings with the terminal shoots remaining showed a 50% rooting in summer.

Hardening

The rooted cuttings were transferred to polythene bags containing potting mixture containing sand, soil and farmyard manure (2:1:1) and hardened in shade house (25% radiation) followed by open sunlight. They were irrigated daily. The survival rate was >40% after hardening. In the first stages of the work, there was a great deal of loss after transplanting the rooted cuttings. Two reasons were observed

1. Transplanting shock
2. Severe rotting of roots

This problem has been solved by monitoring the watering schedules. Watering was done only once a day when in shade house after the cuttings have been transplanted – for three weeks after which they were shifted to open conditions. This helped to reduce root rotting significantly.

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