# Development of Technology for Collection, Processing and Testing Seeds of Five Important Tree Species of Kerala

Final Report of the

**ICFRE-WORLD BANK**
**FORESTRY RESEARCH EDUCATION AND EXTENSION PROJECT**
**(ICFRE Project No. 38-6/97–ICFRE (R); KFRI Project No. KFRI 279/97)**

**K.C. CHACKO**
*Division of Silviculture*

**C. MOHANAN**
*Division of Plant Pathology*

**Kerala Forest Research Institute**
**Peechi 680 653, Kerala, India**

January 2002

# CONTENTS

# 1. PART A

1.1. TITLE OF THE PROJECT : ICFRE World Bank Forestry Research Education and Extension Project Titled: "Development of technology for collection, processing and testing seeds of five important tree species of Kerala".

1.2. NAME OF THE PRINCIPAL INVESTIGATOR (PI) : K.C. Chacko

1.3. ADDRESS OF THE PI : Silviculturist & Scientist-in- Charge
Division of Silviculture
Kerala Forest Research Institute
Peechi 680 653, Thrissur (Dt)
Kerala State

1.4. ICFRE PROJECT NUMBER : No. 38-6/97 ICFRE (R)

1.5. DATE OF START OF THE PROJECT : 06 June 1997

1.6. DATE OF COMPLETION OF THE PROJECT : 06 June 2001

1.7. TOTAL SANCTIONED GRANT OF THE PROJECT (Instalment-wise, half-yearly break up)

| Instalment | I | II | III | IV | V | VI | TOTAL |
|---|---|---|---|---|---|---|---|
| i) Salaries & wages | 42,600 | 42,600 | 42,600 | 42,600 | 42,600 | 42,600 | 2,55,600 |
| ii) Travelling expenses | 20,000 | -- | 20,000 | -- | 10,000 | -- | 50,000 |
| iii) Equipment (Non recurring) | 5,05,000 | -- | -- | -- | -- | -- | 5,05,000 |
| iv) Contingencies Office exp. Etc. (Recurring) | 1,00,000 | -- | 1,00,000 | -- | 1,00,000 | -- | 3,00,000 |
| v) 10% Institutional Administrative charges (except equipment) | 16,260 | 4,260 | 16,260 | 4,260 | 15,260 | 4,260 | 60,560 |
| vi) Any other | -- | -- | -- | -- | -- | -- | -- |
| **Total (Rs.)** | **6,83,860** | **46,860** | **1,78,860** | **46,860** | **1,67,860** | **46,860** | **11,71,160** |

*An amount of Rs. 20,000/- was additionally sanctioned vide letter No. 38-6/97 –ICFRE (R ) dated 29/10/98 for disbursement of salary arrears of the JRF

1.8. TOTAL AMOUNT RECEIVED FROM ICFRE (Instalment wise break up)

| Instalments Received | | | | | | |
|---|---|---|---|---|---|---|
| I | II | III | IV | V | VI | Total |
| 683860 | 130838 | -- | -- | -- | -- | 814698 |

## 2.3. DETAILS OF THE WORKS CARRIED OUT

## 2.3.1. *Acacia nilotica*

### 2.3.1.1. Pod collection and seed extraction

Pods were collected during 1999 and 2000 from Kottathara (Seed zone KL-3, Sub-zone Palakkad). The mature grey coloured pods were collected from the tree by manual shaking using a long pole with a hook. The pods were collected in polythene bags and transported to the laboratory on the same day.

**Experiment 1: Pod dehiscence and extraction of seeds**

The following six treatments were employed:

T1: Air-drying in the laboratory for 48 hours

T2: Oven-drying at 35°C for 48 hours

T3: Oven-drying of water sprayed pods at 35°C for 48 hours

T4: Oven-drying at 45°C for 48 hours

T5: Oven-drying of water sprayed pods at 45°C for 48 hours

T6: Oven-drying of water sprayed pods at 45°C for 24 hours and repeating this process of water spray and drying once again.

Germination studies were carried out using the seeds extracted by the above methods.

**Experiment 2: Seed extraction using seed scarifier**

Pods were oven-dried at 45°C for 4 hours and seeds extracted in an electricaly operated seed scarifier (Agrosaw sample seed scarifier) the drum of which has sand paper. The scarifier was worked for 2 to 3 minutes. The seeds were separated from the chaff using a 5 mm sieve. Extracted seeds were examined for sound and damaged ones and the pods for unreleased seeds.

**Pod and seed characteristics**

Pods collected from different localities (Kottathara, Meenakshipuram, Walayar and Palakkad) of the Sub-zone Palakkad of Zone KL-3 in 1999 April were measured for length, width, number of locules and sound seeds per pod, as well as percentage of deformed and discoloured seeds.

Seed dimensions such as length, width, thickness, and seed weight were also determined. After extraction, sound seeds were selected and the insect-attacked and empty seeds were discarded. For experiments on drying, seed extraction and pre-treatments, seeds collected from Kottathara (Zone- KL-3, Sub-zone Palakkad) were utilised.

## 2.3.1.2. Method of drying and processing

Pod samples were sun-dried for 28-32°C and oven-dried at 45°C and the time when the pods became brittle enough for extraction using a seed scarifier was noted. Each of the treatments had 800 g of pods in four replicates of 44-56 pods. Pods were examined for dryness periodically until they became completely dry. Moisture content (MC%) of pods after sun-drying and oven-drying were determined following Willan (1985).

Seeds from pods dried by both the drying methods were extracted using a seed scarifier. Weight and number of seeds obtained from one kg of pods were recorded. Extracted seeds were grouped into sound, damaged and seeds in pod pieces.

## 2.3.1.3. Method of pod drying and pre-sowing seed treatments

**Experiment 1**: Pods were sun-dried (T1) and oven-dried at 45°C for 2 days (T2) and seeds extracted using a seed scarifier. Percent moisture content (MC%) of seeds, after drying was determined. Extracted seeds were subjected to pre-sowing treatments such as soaking in boiled water for 5 minutes (T1) and scarifying with conc. sulphuric acid for 1 hour followed by soaking in 0.2% $KNO_3$ for 5 minutes (T2). Untreated seeds served as control (T3). For each test, a total of 400 seeds in four replicates were sown in rolled germination towels, which were kept in

beakers containing water in the laboratory condition. Germination was recorded for 20 days.

**Experiment 2**: Seed samples were sun-dried (T1) for 2 days, oven-dried (T2) for two days, and dried in well-lit ventilated room (T3) for 2 days. Seeds were extracted using a motorised seed scarifier as mentioned earlier. Moisture content percentage (MC%) of seeds obtained by different methods was determined. Seeds were pre-treated with conc. $H_2SO_4$ (T2) for one hour and washed well and soaked in 0.2% $KNO_3$ (100 ml/100 seeds) solution for 5 minutes. A total of 200 seeds, equally distributed, in four replicates, were sown for each test in rolled germination towels and germination was recorded for 20 days.

### 2.3.1.4. Media and germination

Pods were oven-dried at 45°C for 4 hours and seeds extracted using a seed scarifier. Extracted seeds were subjected to conc. $H_2SO_4$ (98%) treatment for 10 (T1), 20 (T2), 30 (T3) and 40 (T4) minutes and also in boiled water for 5-10 minutes (T5). The seeds were sown in rolled towel (M1) and quartz sand (M2) of 0.05mm-0.8mm size following ISTA rule (1993). The rolled towel was kept in beakers filled with water in the laboratory condition. Sand was taken in plastic germination trays and maintained in the nursery. Each treatment had 45 seeds in 3 replicates. Moisture percentage of seeds at the time of sowing was determined following ISTA (1993). Germination was noted daily for 25 days. After 25 days, ungerminated seeds were examined for soundness.

### 2.3.1.5. Light and germination

Pods were sun-dried and the seeds extracted. Seeds were pre-treated with conc. $H_2SO_4$ (T2) for one hour and soaked in $KNO_3$ 0.2% for 5 minutes. The seeds were kept for germination in a nursery shed, with translucent roof at various light conditions viz., full (L1), partial (L2) and nil (zero) (L3). Light incident on germinating seeds were measured in terms of photosynthetically active radiation (PAR) using light sensor. Seeds were sown on moistened germination paper placed in trays. Full light was provided by covering the tray with transparent polythene sheet of 150 gauge. Partial light was provided by covering a translucent polythene sheet and total darkness was provided by

covering with black polythene sheet. Four replicates each with 50 seeds were taken for the test. Germination was noted for 20 days. After 20 days, ungerminated seeds were examined for soundness.

### 2.3.1.6. Pre-sowing treatment and germination

**Test No. 1:** Seeds were extracted manually 40 days after collection. Extracted seeds were subjected to the following pre-sowing treatments viz., $H_2SO_4$ (95%) for 5 minutes (T1), $H_2SO_4$ for 10 minutes (T2), $H_2SO_4$ for 30 minutes (T3), hot water (80°C) for 5 minutes (T4), boiled water for 3 minutes (T5) and soaking in tap water for 48 hours (T6); untreated seeds (T7) served as control. Completely randomized design was followed for the experiment. For each treatment a total of 100 seeds in 4 replicates were taken in rolled germination towel. Rolled towels were kept in beakers containing water in laboratory condition. Germination was recorded for 20 days.

**Test No. 2:** Seeds extracted from pods, which were stored for 125 days, were subjected to the following pre-treatments.

T1. $KNO_3$ (0.2%):

Seeds were soaked in $KNO_3$ (0.2%) solution for 5 minutes (500 ml of 0.2% $KNO_3$ was used for saturating the germination paper at the beginning of the test and distilled water was added thereafter for moistening)

T2. $GA_3$ (0.05%):

Seeds were soaked in $GA_3$ (0.05%) solution for 5 minutes (400 ml of 0.05% $GA_3$ was used for saturating the germination paper at the beginning of the test and distilled water was added thereafter for moistening).

T3: Soaking in thiourea (2%) for 12 hours

T4: Soaking in water for 48 hours

T5: $H_2SO_4$ treatment for 30 minutes

T6: Boiled water treatment for 3 hours

T7: Boiled water for 3 minutes

T8: Boiled water treatment + $KNO_3$ (0.2%)

Boiled water treated seeds were kept in germination paper saturated with 500 ml of 0.2 % $KNO_3$. Distilled water was added thereafter for moistening;

T9: Boiled water treatment (3 minutes) + $GA_3$ (0.05%)

Boiled water treated seeds were kept in germination paper saturated with 500 ml of 0.05% $GA_3$. Distilled water was added thereafter for moistening

T10: Soaking of boiled water treated seeds in Thiourea (2%) for 12 hours

T11: Untreated seeds (control).

For control and treatments T1 to T7 a total of 100 seeds in 4 replicates were used. For treatments T8 to T10, 92 seeds in 4 replicates were used. The moisture percentage of seeds at the time of sowing was 16.7. Seeds were sown in rolled germination towels and kept in beakers containing water in the laboratory condition. Germination was recorded everyday for 20 days.

**Test No. 3:** Seeds procured from Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore in January 2000 were subjected to the following pre-sowing treatments.

T1: $H_2SO_4$ treatment for 30 minutes

T2: $H_2SO_4$ treatment for 1hour

T3: Hot water treatment for 5 minutes

T4: Boiled water treatment for 5minutes

T5: Soaking in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 5 minutes

T6: $H_2SO_4$ treatment for 30 minutes followed by soaking in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 5 minutes

T7: $H_2SO_4$ treatment for one hour followed by soaking in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 5 minutes

T8: Soaking in water for 48 hours

T9: Untreated seeds (control).

Completely randomized design was followed for the experiment. A total of 400 seeds were taken for each test in 4 replicates. Seeds were sown in vermiculite and kept in the nursery condition. Germination was recorded for 25 days. Ungerminated seeds were examined for soundness.

**Test No. 4:** Pods were air-dried and seeds were extracted using a seed scarifier. Extracted seeds were subjected to the following pre-sowing treatments.

T1: $H_2SO_4$ (98%) treatment for 1hour (control); Seeds treated with $H_2SO_4$ for 1hour were subjected to the following pre-sowing treatments

T2: Soaked in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 5 minutes

T3: Soaked in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 15 minutes

T4: Soaked in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 25 minutes

For each test a total of 200 seeds were taken in 4 replicates. Seeds were sown in moistened germination towel. Rolled disks were placed in beakers containing water in laboratory condition. Germination was recorded for 22 days. Ungerminated seeds were examined for soundness by cutting test.

**Test No. 5:** Seeds were extracted from air-dried pods using a seed scarifier. Seeds were treated with $H_2SO_4$ (98%) for one hour and subjected to the following pre-sowing treatments

T1: Soaked in $KNO_3$ 0.2% (100 ml/100 seeds) solution for 5 minutes (control)

T2: Soaked in $KNO_3$ 0.4% (100 ml/100 seeds) solution for 5 minutes

T3: Soaked in $KNO_3$ 0.6% (100 ml/100 seeds) solution for 5 minutes

T4: Soaked in $KNO_3$ 0.8% (100 ml/100 seeds) solution for 5 minutes

T5: Soaked in $KNO_3$ 1% (100 ml/100 seeds) solution for 5 minutes

The experiment was laid out in completely randomized design using 200 seeds equally distributed in 4 replicates. Seeds were sown in moistened germination towel. Rolled towels were placed in beakers containing water in

laboratory condition. Germination was noted for 22 days. Ungerminated seeds were analysed.

**Test No. 6:** Seeds were extracted from sun-dried pods using a seed scarifier and subjected to the following pre-sowing treatments:

T1: $H_2SO_4$ treatment for 1hour;

T2: $H_2SO_4$ treatment for 1 hour followed by soaking in $KNO_3$ (0.2%, 100ml/100 seeds) solution for 5 minutes;

T3: $H_2SO_4$ treatment for 1 hour followed by soaking in thiourea (2%, 100 ml/100 seeds) solution for 5 minutes.

For each test, a total of 200 seeds were taken in 4 replicates. Seeds were sown in moistened germination towel. Rolled towels were placed in beakers containing water in laboratory condition. Germination was recorded for 22 days.

## 2.3.2. *Albizia lebbeck*

### 2.3.2.1. Pod collection and seed extraction

Mature pods were collected from the trees with a long pole fixed with a hook. The pods were collected in gunny bags and transported to the laboratory one day after collection. Pods were collected in the years 1998 and 1999.

For the dehiscence and extraction of seeds five different methods were followed.

E1: Air-drying in the laboratory for 48 hours

E2: Oven-drying at 35°C for 48 hours

E3: Oven-drying at 45°C for 48 hours

E4: Oven-drying of water sprayed pods at 45°C for 48 hours

E5: Oven-drying of water sprayed pods at 45°C for 24 hours and this process repeated for 24 hours

Pods were dried in aluminum trays under the above conditions. After the drying period, the pods were observed for complete, partial and lack of dehiscence. In complete dehiscence, the pods split open along sutures and released seeds from the pod; in some cases seeds remained attached. In partial dehiscence the pods split open along one of the two sutures facilitating the

removal of the seeds. The percentage moisture content of seeds soon after dehiscence was measured by following the procedure described in Willan (1985).

### 2.3.2.2. Method of extraction and germination

The seeds extracted by different methods were tested for germination on paper substrate (rolled towel method), after treating the seeds with conc. $H_2SO_4$ for 25 minutes, and boiled water for 10 minutes. The experiment followed completely randomized design with 400 seeds equally distributed in 4 replicates, except for the extraction method E2 and E5. For E2 and E5 there was a shortage of seeds and therefore 48 seeds were used in 4 replicates. Germination was noted everyday for 20 days.

**Pod characteristics**

Pod length, width, number of sound seeds per pod and pods per kg of different samples collected from different locations were determined.

**Seed characteristics**

Seed length, width, thickness and number of seeds per kg and per litre as well as percentage of sound seeds was determined using the seeds collected from different locations. Weight of 1000 seeds was also determined.

### 2.3.2.3. Pre-sowing treatment and germination

**Test No. 1:** Mature pods were collected from a single tree during the year 1998 from Olamattom (Seed zone KL-2, Sub-zone Munnar). Pods were sun-dried and seeds were extracted. Seeds were subjected to three pre- sowing treatments viz., conc. $H_2SO_4$ treatment for 30 minutes (T1), hot water treatment for 5-10 minutes (T2), mechanical scarification and nicking with a needle (T3); untreated seeds (T4) served as control.

For each treatment, a total of 100 seeds were taken in 4 replicates and sown in germination towels. Rolled towels were kept in beakers containing water in the laboratory condition. Germination was noted for 20 days.

**Test No. 2:** The pods were collected from Kuzhalmandam from a single tree (Seed zone KL-3, Sub-zone Palakkad) during the last week of January1999. Seeds

were extracted from pods manually and they were subjected to conc. $H_2SO_4$ treatment for different periods viz., 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55 and 60 minutes (T1 to T12) with an interval of 5 minutes. After the pre-sowing treatment, the seeds were washed well in tap water and kept for germination in rolled germination towels. Rolled towels were vertically placed in beakers containing water in the laboratory condition. For each test, 100 seeds were taken in 4 replicates. Germination was noted for 25 days. Percentage of seedlings with primary leaves was also counted for 25 days.

### 2.3.2.4. Effect of source and pre-sowing treatment on germination

**Test No. 1:** Pods were collected from four different sources (Olamattom, Pottithanni, Chandranagar and Kuzhalmandam), during the different periods of the same harvesting season in the year 1998. Seeds were extracted from pods manually by breaking the pods open. Seeds were kept for germination without any pre-sowing treatment. For each test 100 seeds were taken in four replicates. Seeds were sown in rolled germination towels and kept in beakers containing water in the laboratory condition. Germination was noted for 15 days.

**Test No. 2:** After three months storage, the above seedlots were subjected to various pre- sowing treatments, viz., boiled water treatment for 5-10 minutes (T1) and conc. $H_2SO_4$ 95% (T2) for 10-15 minutes. Sulphuric acid treated seeds were washed and soaked in water for 1hour; untreated (T3) seeds served as control. For each treatment, 100 seeds in 4 replicates were taken. Seeds were sown in rolled germination towels and kept in beaker containing water in the laboratory condition. Germination was recorded for 15 days.

### 2.3.2.5. Media and germination

Pods were collected during the year 1999 from Kuzhalmandam (Seed zone KL-3, Sub-zone Palakkad) during the last week of February 1999. Seeds were extracted from pods manually and sown on different media viz., top of paper (M1), between paper (M2), rolled towel (M3), quartz sand (M4) and vermiculite (M5) (ISTA, 1993). The experiment was conducted using untreated seeds (T1) and also seeds treated with con. $H_2SO_4$ for 25 minutes (T2) following completely

randomized design. Each treatments combination had 400 seeds equally distributed in four replicates.

**M1. Top of paper:** Seeds were sown on moistened germination towels placed in aluminium trays (30 x 30cm) covered with transparent polythene sheet. The medium was maintained moist by spraying water.

**M2. Between paper:** Germination paper was kept on inverted tray kept in a larger tray containing water. The germination towel was kept hanging into the water to facilitate water absorption. Seeds were sown on the paper and covered fully by another moistened germination paper, which extended in to the water in the tray. The whole set up was covered with polythene sheet to reduce the moisture loss.

**M3. Rolled towel:** Seeds were sown in germination towels, rolled and kept in beakers containing water. Towels were further rolled in polythene sheet.

**M4. Quartz sand:** Quartz sand 0.05 mm-0.8 mm as mentioned in ISTA rules, (1993) was taken in plastic germination trays and moistened to 50% of its water retention capacity.

**M5. Vermiculite:** Vermiculite was taken in plastic germination trays and moistened to 50% of its water retention capacity.

All the germination media were kept in the nursery condition (under translucent roof). In each media, treated as well as untreated seeds were sown. The experiment followed completely randomized design. For each treatment 400 seeds were taken in 4 replicates. Germination was recorded for 20 days.

## 2.3.2.6. Effect of different source and media on germination

Pods were collected from 11 different sources viz., S1 (Kuzhalmandam-KAl-1), S2 (Kuzhalmandam-KAl-3a). S3 (Kuzhalmandam-KAl-3b), S4 (Kuzhalmandam-KAl-4), S5 (Karimutty-KAl-10) S6 (Champakkad-CAl-14) S7 (Pottithanni-PAl-1), S8 (Kottathara-KAl-1) S9 (Kottathara-KAl-2) S10 (Meenaksipuram-MAl-1) and S11 (Meenaksipuram-MAl-2) during different periods of the same harvesting season. Seeds were pre-treated with con. $H_2SO_4$ for 25 minutes (T2). Both treated and untreated (T1) seeds were kept for germination. For each test 400 seeds were taken in 4 replicates. Percent moisture

content of seeds was also noted following the procedure described in Willan, (1985). Seeds were sown in rolled towel (M1) and kept in beakers containing water in the laboratory condition. Seeds were also sown in quartz sand (M2). Quartz sand was used according ISTA rules (1993). Sand was wetted to 50% of its water retention capacity. Germination was noted for 20 days. Emergence of first pair of leaves was the germination criterion.

### 2.3.2.7. Effect of light on germination

Pods were collected from two different sources, (Source-1) Champakkad (Seed zone KL-2, Sub-zone-Munnar) and (Source-2) Kuzhalmandam (Seed zone KL-3, Sub-zone Palakkad) during the year 1999 March, February respectively. Seeds were extracted manually. Seeds were pre- treated with con. $H_2SO_4$ (T1) for 25 minutes. Untreated (T2) seeds were also kept for germination. Seeds were sown on top of paper kept in trays (30 cm x 30 cm) and kept in nursery conditions providing different light conditions viz., full (L1), partial (L2) and nil (L3). Full light was provided by covering the trays with transparent polythene sheet. Light intensity in terms of PAR was measured. Partial light was provided by covering the trays with translucent polythene sheet. Nil light condition was provided by covering with black polythene sheet.

All the experiments were carried out in nursery (translucent roof) condition. For each test a total of 400 seeds were taken in 4 replicates. Germination was noted every day for 20 days.

## 2.3.3. *Dalbergia sissoides*

### 2.3.3.1. Pod collection and seed extraction

**Test No. 1:** Pods were collected in the years 1999 and 2000. They were collected in cotton bags and transported to the laboratory on the same day. For the dehiscence and extraction of seeds the following experiments were done.

**Test No.1:** For the dehiscence, the pods were dried in the following methods.

T1: Air-drying in laboratory for 48 hours

T2: Oven-drying at 35°C for 48 hours

T3: Oven-drying at 45°C for 48 hours

T4: Oven-drying of water sprayed pods at 45°C for 48 hours

T5: Oven-drying of water sprayed pods at 45°C for 24 hours and repeating this process for another 24 hours

T6. Oven-drying at 50°C till the pods became brittle

**Test No. 2:** The following treatments were given to the pods and sees extracted using a seed scarifier.

T1: Air-drying for 2 days

T2: Oven-drying at 35°C for 48 hours

T3: Oven-drying at 45°C for 48 hours

T4: Oven-drying of water sprayed pods at 45°C for 48 hours

T5: Oven-drying of water sprayed pods at 45°C for 24 hours and repeating this process for another 24hours

T6. Oven-drying at 50°C till the pods became brittle

**Test No. 3: Extraction using a metal grating:** Brittle pods were dried by sun and oven-drying methods and rubbed on a metal grating prepared out of galvanised iron sheet. Percentage of seeds released by this method was determined.

**Test No. 4: Extraction using a motorised seed scarifier:** Freshly collected pods (D1) as well as pods dried at 50°C (D2) for three hours were subjected to

extraction using a seed scarifier. The drum of the machine had a lining with sand paper. The pods were put into the drum and the machine was worked on for 1 to 1.5 minutes. For both the drying methods 200-300 g pods were taken in three replicates for each locality. After extraction, the sample was analysed for sound, damaged and unreleased seeds.

**Method of extraction and seed purity**

Purity percentage of the seeds extracted using metal sieve and seed scarifier were determined by the procedures given in ISTA (1993).

**Pod and seed characteristics**

Pod length, width, thickness, number of seeds per pod and pods per kg as well as seed length, width, thickness, seeds per kg and weight of 1000 seeds (ISTA, 1993) were determined for samples collected from different localities.

## 2.3.2.2. Methods of drying and germination

Pods were collected in the year 2000 February from different localities (Seed zone KL-3, Sub-zone Palakkad). Seeds were extracted from one sample of pods soon after collection (E1). Other sample was dried in oven (50°C) for 3-4 hours (E2). In both cases, seeds were extracted using a seed scarifier. Extracted seeds were kept for germination in rolled towel and placed in beakers containing water in laboratory condition. A total of 400 seeds in 4 replicates were used for the test. Germination was noted every day for 6 days.

## 2.3.3.3. Germination of seeds with pods intact and after extraction

Pods were collected in the year 1999 from Dhoni (Seed zone KL-3, Sub-zone Palakkad) and Wayanad (Seed zone KL-3, Sub-zone Wayanad). Entire pod, pod pieces and seeds were kept for germination in rolled towel and kept in beakers containing water in laboratory condition. A total of 100 entire pods were taken in 4 replicates, a total of 400 pod pieces and 400 seeds were taken in 4 replicates for the test. Germination was recorded for 15 days.

### 2.3.3.4. Locality and germination

Pods were collected in the year 2000 from different localities (Sholayur, Panthanthode and Peruvaripallam) of Seed zone KL-3 and Sub-zone Palakkad. Seeds were extracted using a seed scarifier. They were sown in rolled towel and kept in beakers containing water in laboratory condition. A total of 400 seeds in 4 replicates were taken for each test. Germination was noted for 10 days.

### 2.3.3.5. Media and germination

Pods were collected in the year 2000 from three different localities (L1: Panthanthode, L2: Peruvaripallam and L3: Sholayur) of Seed zone KL-3 and Sub-zone Palakkad. Seeds were extracted using a seed scarifier. They were kept for germination in different media viz., top of paper (M1), between paper (M2), rolled towel (M3), sand (M4) and vermiculite (M5) in laboratory condition. A total of 400 seeds in 4 replicates were taken for each test. Germination was noted for 10 days.

### 2.3.3.6. Light and germination

**Test No. 1:** Pods were collected in 2000 from Sholayur and Panthanthode (Seed zone KL-3, Sub-zone Palakkad) from single trees. Seeds were extracted using seed scarifier. They were kept for germination in nursery as well as in laboratory at different light conditions viz., partial (L1) and zero light (L2). Germination was noted for 10 days.

**Test No. 2**: Pods were collected in the year 2000 from Panthanthode (Seed zone KL-3, Sub-zone Palakkad). Pods were collected from a single tree (Source 1) and pods collected from two trees were mixed (Source 2). Seeds were extracted using a seed scarifier and kept for germination in nursery under different light conditions viz., full (L1), partial (L2) and nil (zero) (L3). Seeds were sown on moistened germination paper kept in trays. Full light was provided by transparent polythene sheet, partial light by translucent polythene sheet and zero light by black polythene sheet. For each test, 400 seeds in 4 replicates were used. Germination was noted for 10 days.

### 2.3.3.7. Effect of seed size on germination

Pods were collected from Kuppadi (Seed zone KL-3, Sub-zone Wayanad) during the last week of February 1999 and seeds were extracted manually. Seeds were grouped into three categories viz., small (S1), large (S2) and deformed (S3). Moisture content and weight of 400 seeds small and large seeds were determined. A total of 400 small as well as large seeds were kept for germination in four replicates, while all deformed seeds were kept for germination together. After sowing the seeds rolled towels were placed in beakers containing water in the laboratory condition. Germination was noted for 12 days.

## 2.3.4. *Neolamarckia cadamba*

### 2.3.4.1. Fruit collection and processing

Yellow mature fruits were collected during 1998 and 1999 from Kanimangalam (Seed zone KL-2, Sub-zone Malayattur. Fruits were collected from small trees by manual shaking the trees, mostly from ground. Fruits were collected in gunny bags and polythene bags and transported to the laboratory within two days after collection. Fruits were divided into three lots. First lot was kept for sun-drying, second group for oven-drying and the third lot was allowed to rot for 3-4 days. Sun-dried and oven-dried fruits with brittle capsules were rubbed on a metal grater and the released seeds were separated by sieving through a 0.5 mm mesh (Chacko, 1981). Rotten fruits were crushed in water and seeds were separated from the slurry by repeated decantation. Slurry was sun-dried and pure seeds were separated using a 0.5 mm sieve.

**Fruit characteristics**

Fruit length and diameter were determined using vernier calipers, and the number of capsules per fruit was determined by detaching the capsules from single fruits and counting. Number of seeds per capsule was determined by taking out the seeds from capsules and air-drying. Capsule length, capsule width, peduncle diameter and weight of seeds obtained from 1 kg fruit after different methods of extraction were determined. For each test 5 to 10 samples were used in 2 to 3 replicates.

**Seed characteristics**

Seed dimensions such as seed length and seed width were determined with the help of a microscope, which is attached to an image analyzer (Quantimet 500+). Weight of 1000 seeds (ISTA, 1993) and seeds per kg were determined.

## 2.3.4.2. Method of extraction and germination

Fruits collected from Dhoni (Seed zone KL-3, Sub-zone Palakkad) natural forest during the first week of November 1998, were subjected to three different methods of extraction viz., sun-drying (E1), oven-drying (E2) and wet methods (E3).

**E1. Sun-drying:** In this method, the fruits were sun-dried till the capsules became brittle. Dried fruits were rubbed on a metal grater. Fruits broke into small pieces releasing seeds from the capsules. Chaff was removed by winnowing and seeds sieved through a sieve of 0.5 mm mesh size.

**E2. Oven-drying:** Fruits were oven-dried at 50°C till they became brittle. From dried fruits, seeds were extracted as in sun-drying.

**E3. Wet method:** Fruits were kept in trays and allowed to rot for 2-3 days, the rotten fruits were crushed with hands in a bucket of water. The floater and sinker seeds were separated by filtering through filter paper. The seeds were sun-dried. Chaff was removed by winnowing.

Seeds were sown on three different media viz., rolled towel (M1), polyurethane sheet (M2) and sand (M3). Rolled towel was saturated with distilled water. Polyurethane sheet was completely wetted with water by squeezing out the air. Quartz sand of size 0.05 mm-0.8 mm was used according to ISTA rules 1993. Sand was saturated with 50% of its water retention capacity.

The experiment was conducted in the laboratory condition. For each test a total of 800 seeds were used in 4 replicates. Germination was noted every day for 45 days.

### 2.4.2.3. Seed moisture content and purity

Seed moisture content and purity percentage was determined in accordance with ISTA (1993).

### 2.4.2.4. Effect of season of collection and media on germination

Fruits were collected during three periods of the same harvesting season (September, October and November) from a single tree from Dhoni natural forest (Seed zone KL-3, Sub-zone Palakkad) during the year 1998. Fruits were allowed to sun-dry until they became brittle for extraction using a metal sieve. Extracted seeds were sown on different media viz., rolled towel (M1), polyurethane sheet (M2) and sand (M3). Paper substrate was saturated with distilled water and kept in beakers containing water in laboratory condition. Polyurethane sheet was completely wetted with water by squeezing out the air. Sand was used according to ISTA rules. Sand was wetted to 50% of its water retention capacity. The latter two media were kept in the nursery condition. For each test 800 seeds were taken in 4 replicates. Germination was noted everyday for 45 days.

### 2.3.4.5. Light and germination

Freshly fallen fruits were collected from Nellikkuthu (Seed zone KL-3, Sub zone - Nilambur) during the first week of September 1999 and were transported to laboratory and heaped were left for 4 days for partial rotting. The partially rotten fruits were squeezed with hands in water and seeds extracted were separated by decantation and filtering. The seeds were air-dried.

The seeds were sown in Petri-dishes maintained at three light conditions viz., full light (L1), partial light (L2) and zero light (L3). Covering the Petri-dishes with black polythene sheet provided zero light condition white polythene sheet provided partial light condition and glass Petri-dishes without any covering admitted full light. Simple random design was followed for the experiment. Each treatment had 800 seeds with 200 seeds in each of the 4 replicates. The experiment was conducted both in the laboratory (E1) and nursery (E2). Seed germination was noted every day for 45 days.

### 2.3.4.6. Fruit colour and germination

Freshly fallen fruits were collected from Dhoni (Seed zone KL-3, Sub-zone Palakkad) natural forest during the third week of August 1999. Fruits were grouped into different categories viz., very light green (C1), light green (C2), cactus green (C3), greenish yellow (C4), golden yellow (C5) and yellowish brown (C6). Seeds were extracted by squeezing the capsules. Colour of the seeds was also noted. Seeds were air-dried at room temperature for an hour and samples of four replicates of 200 seeds were taken for germination on polyurethane sheet of 27 x 27 cm saturated with tap water and placed in trays (30cm x 30cm). The polythene sheet was maintained moist. Seedling emergence was noted for 45 days.

## 2.3.5. *Tectona grandis*

### 2.3.5.1. Fruit collection and processing

Fruits were collected in the years 1998 and 1999. Mature fruits were harvested from the trees by shaking the branches using a long pole fitted with a hook. Drupes were allowed to fall on plastic sheets spread around the tree. The ground was swept clean before collection. Fruits were collected in jute bags and were transported to the laboratory one day after collection. The calyx was removed by half-filling a bag and vigorously shaking and rubbing.

**Fruit characteristics**

Fruit dimensions such as thickness and diameter with calyx and without calyx, number of locules, number of sound seeds per fruit and number of empty locules per fruit were determined by cutting test. Percentage of sound seeds in a sample, number of seeds per kilogram, seeds per litre and weight of 1000 seeds were determined.

### 2.3.5.2. Influence of sub-zone and tree variation on germination

Fruits were collected in the year 1998 from single trees in three different Sub-zones (Konni, Munnar, Nilambur and Palakkad). Seeds were cleaned off calyx and kept for germination in vermiculite medium. Four hundred seeds were

taken in 4 replicates in each test. Experiment was kept in the nursery shed provided with translucent roof. Germination was noted every day for 45 days.

### 2.3.5.3. Source variation and germination

Seeds collected during 1998-99 from five different areas in Kerala were sown in vermiculite medium. For each source, seeds were taken in 4 replicates. The moisture content of seeds at the time of sowing was determined following the procedure described in Willan (1985). Germination was noted every day for 45 days.

## 2.3.6. Seed pathological studies for all the five species

**1. Selection of trees**

Stands of *Acacia nilotica, Albizia lebbeck, Dalbergia sissoides, Neolamarckia cadamba* and *Tectona grandis* in various localities belonging to different agro-climatic zones in the State were selected for the study. Ten trees of each species were selected in each stand, marked and observations on girth at breast height (gbh) of 1.37 m and height recorded. Phenological details on flowering, fruiting and seed maturation were recorded and seed crop assessment carried out.

**2. Collection of seeds**

Seeds/fruits were collected during 1998 and 1999 seeding seasons from the selected stands of respective tree species. Seeds collected from individual trees in a locality were mixed together and composite samples made. Seed/fruit characteristics, pod size, seed size, seed number per pod, number of locules, etc. were studied. Seed samples were brought to the laboratory, purified, seed weight and moisture levels were assessed. Seeds were sun- or air-dried to reduce the moisture content to 10-15% and stored. Composite samples of each tree species from each locality were stored separately in cloth bags at $25 \pm 2^{\circ}C$.

**3. Laboratory studies**

Working sample from each composite sample was drawn and seeds were further categorized into different groups of apparently healthy, discoloured, deformed and biodeteriorated. Status of fungal and insect infestations was

assessed by dry seed examination method using stereoscopic binoculars. The percentage of discoloured, poorly filled, shrunken and deteriorated seeds in each sample was assessed separately. Seed moisture content was measured by oven-drying method. Weight of seeds from each category as well as from pooled sample was determined separately (ISTA, 1985).

**4. Seed pre-treatment**

To overcome the seed coat dormancy and thereby enhancing the germination potential of seeds, various treatments were carried out. These include:

i) cold water soak - soaking the seeds in water at room temperature for 24 hours.

ii) hot water soak - soaking the seeds in boiling water and keeping them until the water cools down.

iii) acid treatment - soaking the seeds in concentrated sulphuric acid for 5 to 20 min. and washing thoroughly with water.

**5. Seed health testing**

Spermoplane microflora was assessed by employing standard blotter technique (ISTA, 1976). Both sterilized and non-sterilized seeds were screened. Agar plate method (ISTA, 1985) was employed to detect the seed-borne fungi and bacteria. Working sample of 200 to 400 seeds of each species was drawn from each composite sample and tested. Seeds were plated at equal distance in sterile plastic dishes (90-140 mm dia) lined with three moistened germination paper discs (blotter). Both surface sterilized and non- sterilized seeds were tested. Surface sterilization was carried out with 0.01% mercuric chloride for 2 min followed by thorough washing with sterile water. The number of seeds incubated per Petri-dish varied with the size of the seeds. The set ups were incubated at 25 $\pm$ 2°C in a seed germinator fitted with fluorescent lights adjusted at 12 hr dark and light cycles. The incubated Petri-dishes were removed from the seed germinator after 12 days and observations on germination, microbial association, infection on emerging seedlings, etc. recorded. Identification of spermoplane microorganisms was attempted up to generic level or species level in certain cases. Percent incidence of each microorganism was calculated using the following formula.

$$\% \text{ incidence} = \frac{\text{number of seeds recorded with an organism} \times 100}{\text{total number of seeds examined}}$$

Potato dextrose agar medium was used for assessing the spermoplane microflora by agar plate method. Seeds, surface sterilized with 0.01% mercuric chloride and then washed with sterile water, were plated on PDA medium in Petri-dishes and incubated for 7 to 10 days. Microbial colonies developing from the seeds were isolated, purified and identified.

To assess the effect of spermoplane microorganisms (some of which may also be seed-borne) on the germinability of seeds, growing-on test was carried out. Steam sterilized perlite (at 1.0 kg/ $cm^2$ for two hours) was used as the medium. Plastic trays (60 x 30 x 20 cm) were filled with sterilized perlite and the seeds of respective tree species were sown, watered and maintained. Observations on seedling emergence, incidence of disease on seedlings, etc. were recorded up to 30 to 45 days of emergence. The diseased parts from the seedlings were plated aseptically on PDA medium and causal organisms isolated, and identified.

**6. Seed dressing**

Fungicides viz., Thiride (hexathir), Bavistin (carbendazim), Captan (hexacap), were evaluated for their efficacy as seed dressing chemicals. Cleaned seeds of each species were treated with fungicides at the rate of 2 g/kg of seeds in polythene bags (18 x 12 cm) and stored for three weeks. The treated seeds were tested employing blotter method.

## References cited in Methodology

Chacko, K.C. 1981. A simple method for the extraction of seeds of *Anthocephalus chinensis*. Evergreen 7: 3.

ISTA 1976. International rules for seed testing *Seed Science and Technology* 4: 3-49

ISTA 1985. International rules for seed testing. *Seed Science and Technology* 13: 299-355.

ISTA 1993. International rules for seed testing. *Seed Science and Technology* 21:1-259.

Prasad R., Kandya, A.K, 1992. Handling of Forestry Seeds in India. New Delhi, India: Associated Publishing Company, 420p.

Willan, RL. 1985. A guide to forest seed handling. FAO Rome, 379 p.

## 2.4. Results and Discussion

### 2.4.1. *Acacia nilotica*

### Seed collection areas

*Acacia nilotica* seed trees are available in Zone 2 (KL-2) and Zone 3 (KL-3) whereas they are absent in Zone 1 (KL-1). In Zone 2 seed trees are located at Champakkad, in Munnar Sub-zone. In Zone 3, seed trees were located at Walayar, Naikkapadi, Kottathara, Vandithavalam and Meenakshipuram in Palakkad Sub-zone. They are distributed in the dry deciduous forests (Chinnar and Attapadi) up to 600 m.s.l. Mostly they occur only as isolated trees (Agali, Champakkad and Meenakshipuram), or in small of small patches in cultivated lands (Walayar and Meenakshipuram) wastelands (Kottathara), and railway embankments (Walayar). Tallest tree in the study area had a height 19.9m [at Meenakshipuram (MAn-19)]. Maximum girth measured was 206 cm for a tree at Walayar (KPLAn-3). Details of height and gbh are given in Table 1.

**Table 1. *A. nilotica* seed collection areas in Kerala**

| Seed zone | Sub-zone | Locality | Tree No. | GBH (cm) | Height (m) |
|---|---|---|---|---|---|
| KL-2 | Munnar | Champakkad | CAn-1 | 114 | 13 |
| | | | CAn-2 | 164 | 18 |
| | | | CAn-3 | 147 | 17 |
| KL-3 | Palakkad | Walayar | WAn-1 | 158 | 15 |
| | | | WAn-2 | 94.5 | 12 |
| | | | WAn-3 | 59 | 08 |
| | | | WAn-4 | 120.5 | 15 |
| | | | WAn-5 | 120 | 14 |
| | | | WAn-6 | 121 | 14 |
| | | | WAn-7 | 112 | 15 |
| | | | WAn-8 | 114.5 | 15 |
| | | | WAn-9 | 121.5 | 13 |
| | | | WAn-10 | 123 | 14 |
| | | Kanalpiriv | KPLAn-1 | 36 | 06 |
| | | | KPLAn-2A1 | 98 | 12 |
| | | | KPLAn-2A2 | 94 | -- |
| | | | KPLAn-3 | 206 | 15 |
| | | | KPLAn-4 | 155 | 11 |
| | | | KPLAn-5 | 127 | 12 |
| | | | KPLAn-6A1 | 141 | 18 |
| | | | KPLAn-6A2 | 160 | -- |
| | | | KPRAn-1 | 89 | 08 |
| | | | KPRAn-2 | 160 | 15 |
| | | | KPRAn-3A1 | 21 | 05 |

| | | | | | |
|---|---|---|---|---|---|
| | | | KPRAn-3A2 | 34 | -- |
| | | | KPRAn-4 | 60 | 9 |
| | | | NAn-1 A1 | 97 | 15 |
| | | | NAn-1A2 | 72 | -- |
| | | | NAn-2 | 54 | 06 |
| | | | KAn-3 | 117 | 12 |
| | | | KAn-4 | 63 | 8 |
| | | | KAn-5 | 57 | 08 |
| | | | KAn-6 | 27 | 08 |
| | | | KAn-7 | 162 | 10 |
| | | Naikkarpadi | KAn-8 | 39 | 08 |
| | | | KAn-9 | 82 | 07 |
| | | | KAn-10 | 68 | 09 |
| | | Kottathara | KAn-11A1 | 90 | 12 |
| | | | KAn-11A2 | 65 | -- |
| | | | KAn-12 | 74 | 12 |
| | | | KAn-13 | 88 | 11 |
| | | | KAn-14 | 70 | 11 |
| | | | KAn-15 | 94 | 11 |
| | | | KAn-16A1 | 42.5 | 11 |
| | | | KAn-16A2 | 49.5 | --- |
| | | | KAn-17 | 125 | 11 |
| | | | KAn-18 | 51 | 07 |
| | | | KAn-19 | 96.5 | 10 |
| | | | KAn-20 | 72 | 07 |
| | | | VAn-1A1 | 165 | 16 |
| | | | VAn-1A2 | 152 | 09 |
| | | | VAn-2 | 90 | 16 |
| | | | MAn-3 | 107 | 9 |
| | | | MAn-4 | 126 | 14 |
| | | | MAn-5 | 55 | 16 |
| | | | MAn-6A1 | 73 | 11 |
| | | | MAn-6A2 | 50 | --- |
| | | Vandithavalam | MAn-7A1 | 86 | 12 |
| | | | MAn-7A2 | 69 | --- |
| | | | MAn-8 | 122 | 16 |
| | | Meenakshipuram | MAn-9 | 107 | 13 |
| | | | MAn-10 | 85 | 11 |
| | | | MAn-11 | 97 | 10 |
| | | | MAn-12 | 67 | 16 |
| | | | MAn-13A1 | 193 | 14 |
| | | | MAn-13A2 | 87 | --- |
| | | | MAn-14 | 68 | 14 |
| | | | MAn-16 | 159 | 20 |
| | | | MAn-17 | 53 | 10 |
| | | | MAn-18 | 75 | 14 |
| | | | MAn-19 | 79 | 20 |
| | | | MAn-20 | 87 | 13 |

*A1 and A2 refers to two stems arising from the base

CAn-1: Champakkad *Acacia nilotica* number 1; WAn-1: Walayar *Acacia nilotica* number 1;KPLAn-1: Kanapiriv left *Acacia nilotica* number 1;KPRAn-1: Kanal piriv right *Acacia nilotica* number 1; NAn-1: Naikarpadi *Acacia nilotica* number 1; KAn-1: Kottathara *Acacia nilotica* number 1: VAn-1: Vandithavalam *Acacia nilotica* number 1: MAn-1: Meenakshipuram *Acacia nilotica* number 1

## Phenology of flowering and fruiting

The flowering season varies within and between localities. Flowering was observed almost throughout the year. Pods are available during March-May. However major seed collection period is April. Maximum fruiting was observed at Kottathara (Zone-3, Palakkad Sub-zone), in the year 1999 and 2000. The details of flowering, fruit crop assessment and fruit collection period are given in Table 2.

**Table 2. Flowering and fruiting of *A. nilotica* in different areas**

| Zone | Seed Sub-zone | Locality | Year | Flowering period | Fruit collection period | Seed crop |
|---|---|---|---|---|---|---|
| KL-2 | Munnar | Champakkad | 1998 | May | April | Poor |
| KL-3 | Palakkad | Walayar | 1998 | February, May, July | March, April | Poor |
| | | | 1999 | January | March, April | Poor |
| | | Meenakshipuram | 1998 | March, May, | March, April | Poor |
| | | | 1999 | June | | |
| | | Kottathara | 1998 | May, July, September, November | March-April April | Poor |
| | | | 1999 | April | April | Average |
| | | | 2000 | April May | May | Good |

## 2.4.1.1. Pod collection and seed extraction

### Colleetion

The pods (Plate I) were collected from the tree by manual shaking using a long pole with a hook when they were grey in colour. Pods falling on ground were mostly eaten away by cattle as observed in Kottathara, Walayar and Meenakshipuram.

**Seed extraction:**

**Experiment 1: Seed extraction by different pod drying methods**

Dehiscence was substantially improved in all the oven-drying treatments (Table 3). Oven-drying combined with water spraying improved dehiscence probably due to the uneven drying of the pod surface. However none of the treatments could improve the dehiscence. The decrease in the germination in oven-drying extraction methods needs further investigation.

**Table 3. Percentage pod dehiscence, seed moisutre content and germination percentage of *A. nilotica* dried under different conditions**

| Treatment No. | Extraction method | % of dehiscence after 2 days of drying | | | | MC% of seeds soon after dehiscence | % of germination at 40 days after sowing |
|---|---|---|---|---|---|---|---|
| | | Full | Partial | Total (Full +Parial) | Nil | | |
| E1 | Drying in the laboratory for 24h | 1.5 | 79.1 | 80.6 | 19.4 | 21.44 | 26 |
| E2 | Oven-drying at 35°C for 24h | 0 | 97.5 | 97.5 | 2.5 | 8.9 | 5 |
| E3 | Oven-drying at 45°C for 24h | 1.2 | 89.39 | 90.41 | 9.5 | 15.81 | 20 |
| E4 | Oven-drying of water sprayed pods at 45°C for 24h | 2.41 | 92.9 | 95.31 | 4.7 | 15.02 | 17.5 |
| E5 | Oven-drying water sprayed pods at 45°C for 24 hours and this process repeated for 24 h | 0 | 97.5 | 97.5 | 2.5 | 13.83 | 15 |

**Experiment 2: Seed extraction using seed scarifier (Agrosaw seed scarifier)**

As none of the drying methods resulted in complete dehiscence of pods within a short period, it was felt necessary to try a mechanical method for easy extraction of seeds. For this, a motorised seed scarifier (Plate 2), with drum lined with sand paper, was employed. As the machine was operated for 2-3 minutes the brittle pods broke into pieces releasing the seeds (Plate 3). The seeds were separated from the chaff using a 5 mm sieve.

Samples were drawn from the extracted seeds and examined for physical damage. Only up to 2% of them were damaged in the process. The trial was repeated for three to four times and the result was found excellent, needing no formal experiment to confirm. However, a small fraction (%) of the seeds remained unreleased which could be extracted by repeating the process.

**Pod charcteristics**

Pods measure 13-17 cm in length, 1.6-1.8 cm in width and contains 6-8 seeds. One thousand seeds weighed 140 -160 g. Details are given in Table 4.

**Table 4. Pod charcteristics of *A. nilotica* from different localities of the State**

| Seed/Pod characteristics (mean) | Localities | | | |
|---|---|---|---|---|
| | Kottathara | Meenakshipuram | Palakkad | Walayar |
| Length of pod (cm) | 15.00 | 14.49 | 14.57 | 15.89 |
| Width of pod (cm) | 17.00 | 1.67 | 1.64 | 1.80 |
| No. of locules | --- | 7.00 | 6.80 | 6.60 |
| No. of seeds per pod | 8 | 6.80 | 6.80 | 6.40 |
| % discoloured and deformed seeds | --- | 50.00 | 50.00 | 45.00 |
| Wt. of 1000seeds (g) | 160 | 140.50 | 150.20 | 140.80 |
| Number of seeds per kg pod | 1325 | -- | -- | -- |
| % Moisture content | --- | 5.60 | 7.6 | 6.80 |

-- data not available

**Seed characteristics**

Seeds measure 0.81-0.92 cm in length, 0.6-0.73 cm in width and 0.29-0.32 cm in thickness. One kilogram contains 5900-6500 seeds. Details are given in Table 5.

**Table 5. Seed characteristics of *A. nilotica***

| Tree number | Mean | | | |
|---|---|---|---|---|
| | Seed length (cm) | Seed width (cm) | Seed thickness (cm) | Seeds\kg |
| AAn-18 | 0.85 (0.118) | 0.69 (0.034) | 0.31 (0.069) | --- |
| AAn-6 | 0.81 (0.058) | 0.69 (0.0413) | 0.29 (0.060) | 5900-6500 |
| AAn-8 | 0.81 (0.057) | 0.67 (0.065) | 0.03 (0.085) | --- |
| AAn-8a | 0.92 (0.0352) | 0.73 (0.049) | 0.32 (0.023) | --- |
| AAn-13 | 0.84 (0.073) | 0.704 (0.0743) | 0.31 (0.042) | --- |

--- data not available
(figures in parenthesis S.E. of mean value)

## 2.4.1.2. Method of drying and processing

Pods dried by oven method (45°C) took 48 hours to became brittle whereas pods dried in sunlight took only 12 hours to become brittle. Details of seed extraction are given in Table 6.

**Table 6. Output and moisture content of *A. nilotica* seeds after different extraction methods**

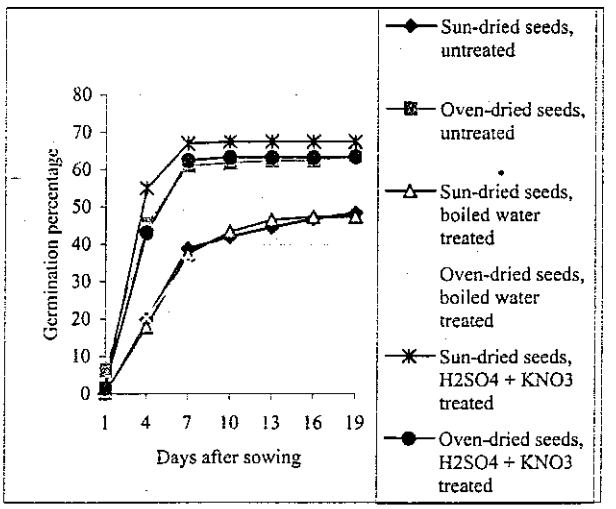
| | Sun-dry | Oven-dry |
|---|---|---|
| Quantity of seed obtained from 1 kg pod (g) | 201.4 | 222.85 |
| Number of seeds/kg pod | 1325 | 1375 |
| % of damaged seeds | 1.07 | 0.08 |
| % of unreleased seeds | 4.54 | 10.32 |
| % of sound seeds | 94.38 | 87.92 |
| MC% of sound seeds | 26.11 | 23.50 |

Considering the output of sound seeds obtained, sun-drying the pods for 2 days is the easiest and efficient method.

## 2.4.1.3. Methods of drying and germination

**Experiment 1:** Method of drying is important in germination of *Acacia nilotica* seeds. Seeds extracted after oven-drying gave 64% germination in 20 days after sowing without any pre-sowing treatment, whereas seeds extracted from sun-dried pods gave only 48% germination. The MC% of seeds extracted from oven-dried pods was 25%, whereas seeds extracted from sun-dried pods were 11.8%. Maximum germination (68%) was obtained for sun-dried seeds treated with $H_2SO_4$ for 1 hour followed by $KNO_3$ (0.2%) solution for 5 minutes. The details of germination are given in Figure 1.

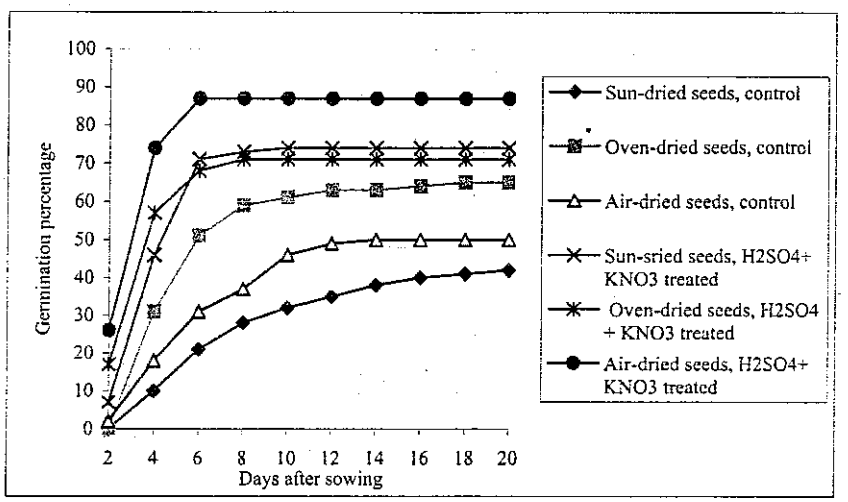
**Figure 1. Germination of *A.nilotica* seeds extracted from pods dried by different methods**




**Experiment 2:** Seeds dried in oven at 45°C gave 66% germination in 20 days after sowing without any pre- sowing treatment, whereas sun-dried and air-dried seeds gave 42% and 50% percent germination respectively. MC% of sun-dried seeds was 19%, oven-dried seeds 20%, and air-dried seeds 20.5%, the difference being

negligible. But pods dried at 45°C in oven environment gave maximum germination. Perhaps the temperature of 45°C has an enhancing effect on germination of *A. nilotica* seeds. Pre-treated seeds in all the methods gave maximum germination. The maximum germination was obtained for air-dried seeds after the pre-sowing treatment ($H_2SO_4$ + $KNO_3$). The details are given in Figure 2.

**Figure 2.Germination percentage of *A. nilotica* seeds extracted by drying the pods by different methods**




## 2.4.1.4. Media and germination

For the germination of *A. nilotica* seeds, paper substrate is the better medium compared to sand probably because of the adequacy of moisture supply in germination paper than in quartz sand. The details are given in Table 7.

**Table 7. Effect of media on germination**

| Treatment code | Pre-sowing treatment | % germination at 25 days after sowing | | Number of days taken for commencement germination | | % ungerminated healthy seeds | |
|---|---|---|---|---|---|---|---|
| | | Rolled towel | Quartz sand | Rolled towel | Quartz sand | Rolled towel | Quartz sand |
| T1 | $H_2SO_4$ (10 minutes) | 15.56 | 8.88 | 4 | 8 | 20.00 | 46.66 |
| T2 | $H_2SO_4$ (20 minutes) | 31.11 | 8.88 | 3 | 8 | 40.00 | 40.00 |
| T3 | $H_2SO_4$ (30 minutes) | 20.00 | 4.44 | 3 | 11 | 40.00 | 40.00 |
| T4 | $H_2SO_4$ (40 minutes) | 24.44 | 26.67 | 3 | 7 | 12.50 | 44.44 |
| T5 | Boiled water | 17.78 | 4.44 | 4 | 7 | 35.55 | 37.77 |
| T6 | Control | 37.78 | 28.89 | 4 | 8 | 28.00 | 31.11 |

## 2.4.1.5. Light and germination

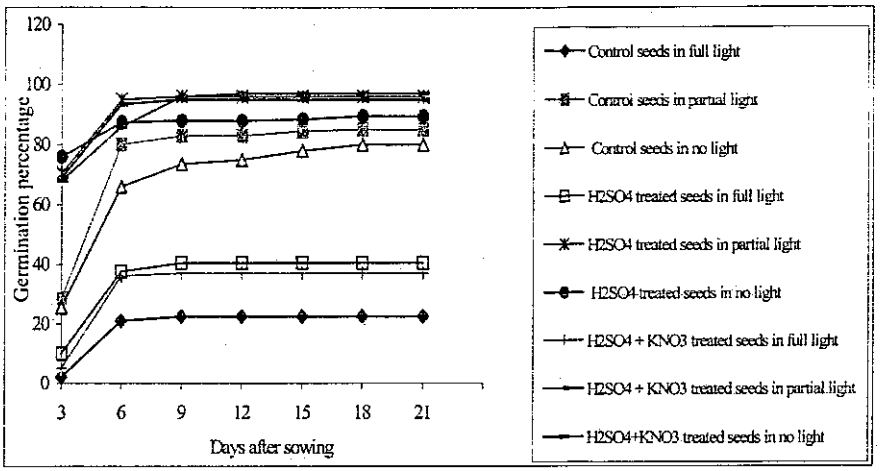
Photosynthetically active radiation (PAR) provided for different light conditions is given in Table.8.

**Table 8. Details regarding the light conditions provided for the experiment**

| Type of covering | Quantity of Photosynthetically Active Radiation (micromole /$m^2$/s) | | |
|---|---|---|---|
| | Laboratory | Nursery shed | Open ground |
| Nil | 8 | 216 | 1619 |
| Transparent sheet | 6 | 197 | 1535 |
| Translucent sheet | 4 | 138 | 1095 |
| Black polythene sheet | 0 | 0 | 0 |

Of the three light conditions tested, *A. nilotica* seeds gave maximum germination (96%) in partial light condition. Seedlings remained yellow in colour till they were exposed to sunlight. When exposed to sunlight, cotyledonary leaves gradually turned green. Zero light is the next best for germination. Full light had an inhibitory effect on germination. The details are given in Figure 3.

**Figure 3. Effect of light on germination of *A. nilotica* seeds**




## 2.4.1.6. Pre-sowing treatment and germination

**Test No. 1:** Pre-treatment with boiled water gave the best results (77%). $H_2SO_4$ treatment for 10 minutes and 30 minutes gave 64% germination. This supports an earlier observation that boiling water is the best method of pre-sowing treatment for *A. nilotica* seeds (FRI, 1983). Details are given in Table 9.

**Table 9. Effect of pre- sowing treatment on germination of *A. nilotica* seeds**

| Treatment code | Pre sowing treatment | % of germination at 20 days after germination | Number of days taken for commencement of germination |
|---|---|---|---|
| T1 | $H_2SO_4$ (5 minutes) | 40 | 1 |
| T2 | $H_2SO_4$ (10 minutes) | 64 | 2 |
| T3 | $H_2SO_4$ (30 minutes) | 64 | 2 |
| T4 | Hot water (5 minutes) | 43 | 3 |
| T5 | Boiled water (3 minutes) | 77 | 3 |
| T6 | Soaking in tap water (48hours) | 28 | 5 |
| T7 | Control | 44 | 3 |

**Test No. 2:** Maximum germination (51%) was obtained for seeds treated with con. $H_2So_4$ for 1 hour and then soaked in $KNO_3$ (0.2%) for 5 minutes, whereas Sulphuric acid alone treatment could give only 28% germination. This shows the

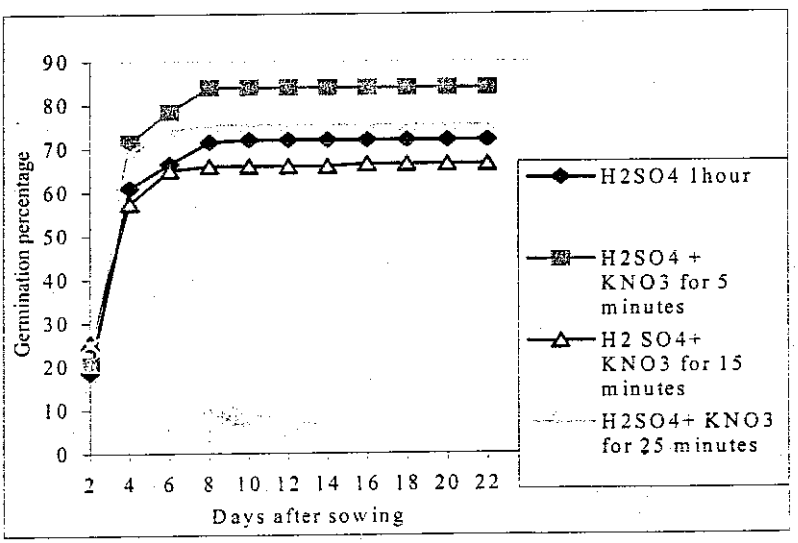
positive role of $KNO_3$ 0.2% promoting germination of sulphuric acid-treated seeds. The details of germination are given in Table 10.

**Table 10. Effect of pre-sowing treatment on germination of *A. nilotica* seeds**

| Treatment code. | Pre sowing treatment | % of germination at 20 days after sowing | Number days taken for commencing germination | % of ungerminated healthy seeds |
|---|---|---|---|---|
| T1 | $H_2SO_4$ (95 %) 30 minutes | 13.5 | 7 | 19.75 |
| T2 | $H_2SO_4$ (95%) 1 hour | 28 | 8 | 11.25 |
| T3 | Hot water (5 minutes) | 46 | 8 | 3.25 |
| T4 | Boiled water (3 minutes) | 40.25 | 8 | 0.25 |
| T5 | $KNO_3$ (0.2%) 5 minutes | 21 | 8 | 23.5 |
| T6 | $H_2SO_4$ (95 %) 30 minutes + $KNO_3$ (0.2%) 5 minutes | 20.5 | 7 | 18.75 |
| T7 | $H_2SO_4$ (95 %) 1 hour + $KNO_3$ (0.2%) 5 minutes | 51.25 | 7 | 9.75 |
| T8 | Soaking in water for 48 hours | 19.75 | 6 | 25.25 |
| T9 | Control | 17.5 | 7 | 34.75 |

**Test No.3:** Prolonging the duration of $KNO_3$ (0.2%) treatment did not enhance the germination percentage on the other hand it lowered the germination percentage. The details are given in Figure 4.

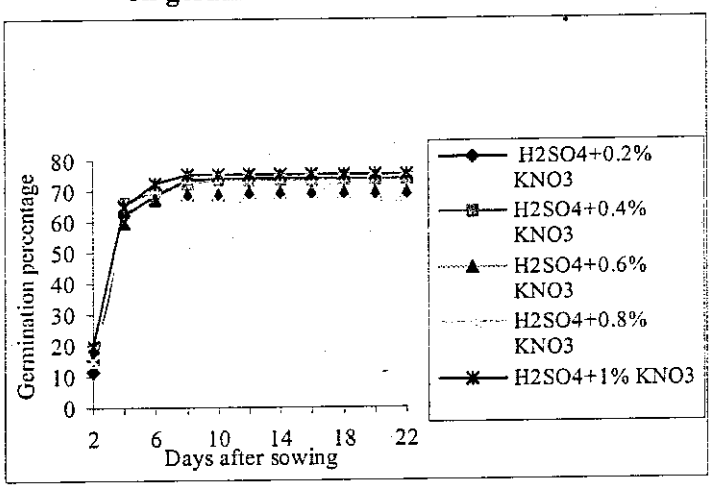
**Figure 4. Effect of duration of $KNO_3$ (0.2%) treatment on germination of *A. nilotica* seeds**



Earlier, Palani *et al.* (1995) reported that seeds treated with sulphuric acid for one hour and soaked in 2% $KNO_3$ solution for 24 hours can enhance germination to 85%. From the above tests it is evident that only 0.2% solution of $KNO_3$ is needed and the treatment period can be reduced to 5 minutes instead of 24 hours.

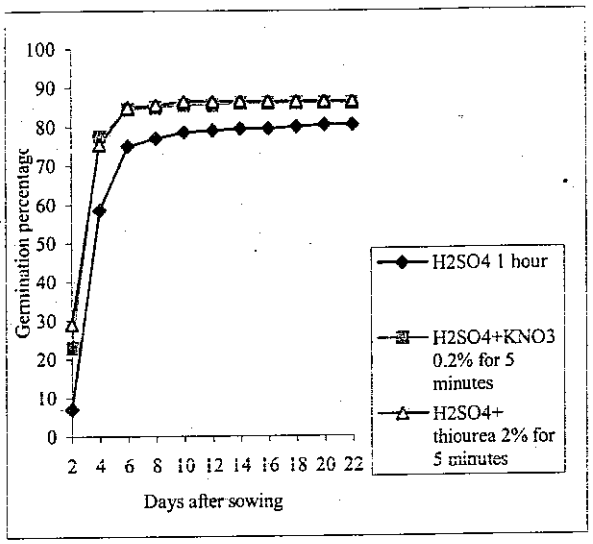
**Test No. 4:** This particular test was done to further confirm the effect of various concentrations of $KNO_3$ solution in promoting germination of *A. nilotica* seeds. However, increase in concentration has little effect on seed germination (Figure 5) confirming our earlier finding in favour of 0.2% $KNO_3$ solution.

**Figure 5. Effect of different concentrations of $KNO_3$ on germination of *Acacia nilotica* seeds**




**Test No. 5:** Results obtained from this test showed no advantage of using Thiourea 2% over 0.2% $KNO_3$ solution in improving germination. The details are presented in Figure 6.

**Figure 6. Effect of different pre-sowing treatments on germination of *A. nilotica***




## 2.4.1.7. Seed pathology of *A. nilotica*

**Seed/fruit characteristics and dry seed examination**

*A. nilotica* seeds collected from Meenakshipuram, Palakkad and Walayar were found infested with spermoplane microorganisms and the percentage of discoloured and deformed seeds was around 50 (Table 4). The fruit/seed characteristics varied considerably. Seed weight (weight of 100 seeds) recorded for the pooled sample from each locality ranged from 14.5 to 15.2 g. Per cent moisture content also ranged from 5.6-7.6. Dry seed examination recorded fungal fructifications, sclerotia, mycelial mats, etc. especially on discoloured, shrivelled, and deformed seeds. Seedlots from Meenakshipuram and Palakkad recorded high percent discoloured and deformed seeds.

**Seed microflora**

Seeds of *A. nilotica* harboured a rich microflora comprising 18 fungal genera, mycelia sterilia, bacteria and actinomycetes. Seedlot from Palakkad recorded highest number of spermoplane microbes (22) while those from Meenakshipuram recorded the least (12) (Table 11-13). Seeds that were not surface sterilized (blotter

method) recorded maximum number of microbes as well as their high percent incidence. Among storage fungi *Aspergillus* spp., *Penicillium* spp. and *Trichoderma* spp. were the predominant ones. *Beltrania* sp., *Botryodiplodia theobromae, Colletotrichum gloeosporioides, Coniella* sp., *Drechslera* sp., *Fusarium* sp. and *Phoma* sp. were the important field fungi recorded on seeds from all the three localities. Surface sterilization of seeds with 0.01% mercuric chloride excluded most of the spermoplane microorganisms and their number was reduced to 5-7 and the percent incidence was very less (Table 11-13). For example, in seed samples from Meenakshipuram, surface sterilizaton excluded all the storage fungi, except *Aspergillus* spp. from the seeds (Table 12). Similarly in seed samples from Walayar only four fungi, viz. *Aspergillus niger*, *Chaetomium* sp., *Drechslera* sp., and *Trichoderma* sp. were encountered after the surface sterilization. Though, bacteria were present in all the three samples, their intensity of infection and percent incidence could be reduced by the treatment. Similarly, cold water, hot water, and sulphuric acid treatments performed in order to enhance the germinability of seeds, also excluded most spermoplane microflora from all the three seed samples tested.

Agar plate method, in which surface sterilized seeds were plated on potato dextrose agar medium yielded comparatively a few spermoplane microbes. Field fungi like *Fusarium* sp., *Coniella* sp. *Beltrania* sp., *Curvularia* sp., *Phoma* sp., etc. were detected using this method. In blotter test and agar plate method, seeds severely infested with *Fusarium* spp. exhibited seed rot and the seedlings emerging from such seeds became infected with the fungus.

**Growing - on test**

Seeds collected from Meenakshipuram were utilized for growing-on test. Seedling emergence started 4 to 8 days after sowing in sterile perlite medium and continued up to 12 days. Most of the seedlings emerged within 8-10 days. Percent germination was found lower (65%) than those obtained in blotter tests.

**Table 11. Spermoplane microorganisms detected from seeds of *A. nilotica* (1998 Walayar seedlot) by blotter and agar methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | | | Agar plate method %incidence |
|---|---|---|---|---|---|---|---|
| | | NSS* | SS | CW | HW | A | |
| 1 | *Alternaria* sp. | | - | - | | 4 | |
| 2 | *Aspergillus* sp. | | | 8 | | 4 | |
| 3 | *Aspergillus niger* | 4 | 27 | | 8 | 6 | 10 |
| 4 | *Beltrania* sp. | | 5 | | | | 2 |
| 5 | *Botryodiplodia theobromae* | | 2 | | | | |
| 6 | *Chaetomium* sp. | 6 | 14 | | | | |
| 7 | *Colletotrichum gloeosporioides* | | 1 | | | | |
| 8 | *Coniella* sp. | | 4 | | | | |
| 9 | *Curvularia* sp. | | | | 2 | | 2 |
| 10 | *Dreschslera* sp. | 5 | 1 | | | | |
| 11 | *Fusarium* sp. | | 8 | | 8 | | 12 |
| 12 | *Mucor* sp. | | 9 | 6 | | | |
| 13 | *Paecilomyces* sp. | | | | 6 | | |
| 14 | *Penicillium* sp. | | 7 | | 14 | | |
| 15 | *Pestalotia* sp. | | 4 | | | | |
| 16 | *Phoma* sp. | | 5 | | | | |
| 17 | *Trichoderma* sp. | 5 | 8 | 8 | | 6 | |
| 18 | *Verticillium* sp. | 1 | | 2 | | | |
| 19 | Sterile mycelium (black) | | 5 | | | | 8 |
| 20 | Sterile mycelium (white) | | 4 | | | | |
| 21 | Bacteria | 10 | 22 | | 10 | 12 | 6 |
| 22 | Actinomycetes | 1 | 10 | | | | |

*NSS: Non-surface sterilized; SS: Surface sterilized; CW: Cold water treatment;
HW: Hot water treatment; A: Sulphuric acid treatment

**Table 12. Spermoplane microorganisms detected from seeds of *A. nilotica* (1998 Meenakshipuram seedlot) by blotter and agar methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | | |
|---|---|---|---|---|---|---|
| | | NSS* | SS | CW | HW | A |
| 1 | *Alternaria* sp. | 3.00 | | | | |
| 2 | *Aspergillus* sp. | 7.00 | 6.00 | 2.00 | 8.00 | 3.00 |
| 3 | *Aspergillus niger* | 14.50 | | | | |
| 4 | *Curvularia* sp. | | | 3.00 | | |
| 5 | *Fusarium* sp. | 14.00 | 5.00 | 4.00 | | |
| 6 | *Mucor* sp. | 0.50 | | | | |
| 7 | *Paecilomyces* sp. | 0.25 | 10.00 | | | |
| 8 | *Penicillium* sp. | 8.75 | | | | |
| 9 | *Phoma* sp. | | 2.00 | | | |
| 10 | *Trichoderma* sp. | 1.25 | | 1.00 | | 2.00 |
| 11 | *Verticillium* sp. | | | 2.00 | | |
| 12 | Sterile mycelium (black) | | | 3.00 | | |
| 13 | Sterile mycelium (white) | | 3.00 | 4.00 | 7.00 | |
| 14 | Bacteria | 16.00 | 10.00 | 13.00 | 14.00 | 12.00 |
| 15 | Actinomycetes | 23.00 | 2.00 | | 10.00 | |

*NSS: Non-surface sterilized; SS: Surface sterilized; CW: Cold water treatment;
HW: Hot water treatment; A: Sulphuric acid treatment

**Table 13. Spermoplane microorganisms detected from seeds of *A. nilotica* (1998 Palakkad seedlot) by blotter and agar methods and their per cent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | | | Agar plate method %incidence |
|---|---|---|---|---|---|---|---|
| | | NSS* | SS | CW | HW | A | |
| 1 | *Alternaria* sp. | | | | 2.00 | 2.00 | 4.00 |
| 2 | *Aspergillus* sp. | 17.00 | 4.00 | 2.00 | | | |
| 3 | *Aspergillus niger* | 3.00 | | | | | 2.00 |
| 4 | *Beltrania* sp. | 5.00 | | | | | 2.00 |
| 5 | *Bipolaris* sp. | 3.00 | | | | | |
| 6 | *Chaetomium* sp. | 10.00 | | 4.00 | 5.00 | | |
| 7 | *Cephalosporium* sp. | 1.50 | | | | | |
| 8 | *Cercospora* sp. | 1.50 | | | | | |
| 9 | *Curvularia* sp. | 1.00 | | | 5.00 | 5.00 | |
| 10 | *Cladosporium* sp. | 1.50 | | | | | |
| 11 | *Dreschslera* sp. | 3.75 | | | | | |
| 12 | *Fusarium* sp. | 0.50 | | | | | |
| 13 | *Gliocladium* sp. | 7.00 | 4.50 | 3.00 | 3.00 | | 7.00 |
| 14 | *Mucor* sp. | 1.25 | | | | | |
| 15 | *Paecilomyces* sp. | 4.00 | | | | | |
| 16 | *Penicillium* sp. | 6.75 | 3.50 | | 2.00 | | |
| 17 | *Pestalotia* sp. | 0.50 | | | | | |
| 18 | *Phoma* sp. | 4.00 | | | | | 4.00 |
| 19 | *Trichoderma* sp. | 11.00 | | 6.00 | 2.00 | | 3.00 |
| 20 | *Verticillium* sp. | 4.20 | | | 2.00 | | |
| 21 | Sterile mycelium (white) | | 4.00 | 7.00 | 2.00 | 7.00 | 2.00 |
| 22 | Bacteria | 19.50 | 10.00 | 10.00 | 10.00 | 6.00 | 4.00 |

*NSS: Non-surface sterilized; SS: Surface sterilized; CW: Cold water treatment; HW: Hot water treatment; A: Sulphuric acid treatment

**Plate 1. Pods of *A. nilotica***

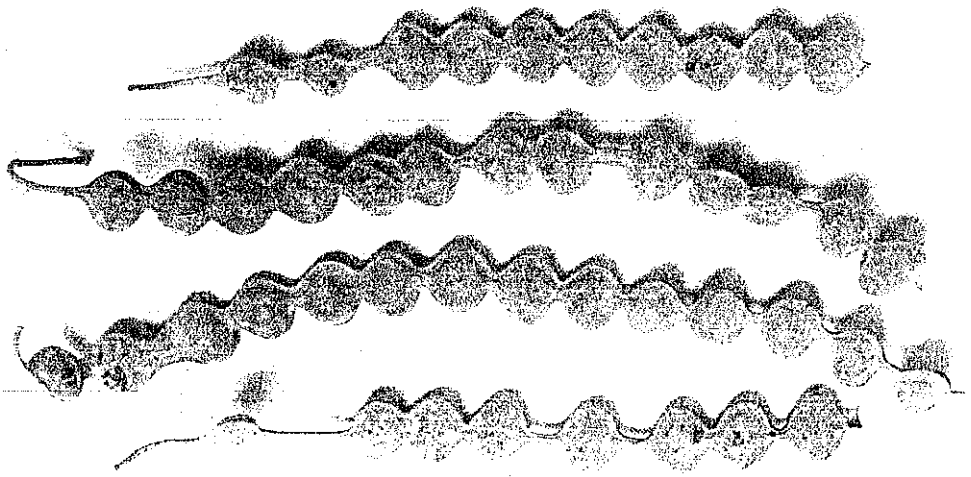


**Plate 2. Agro saw Seed scarifier (electric)**

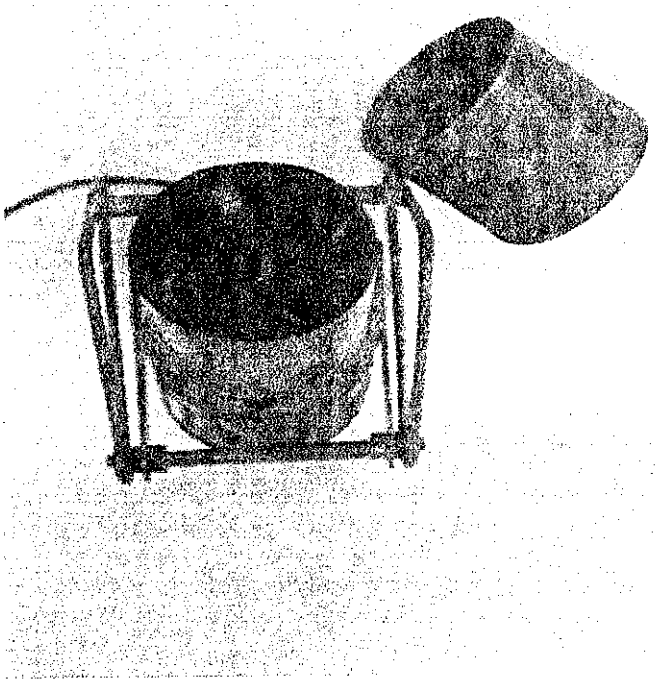


**Plate 3.** 1. *A. nilotica* seeds extracted by hand 2. Seeds extracted with the help of a seeds scarifier

1. 2.

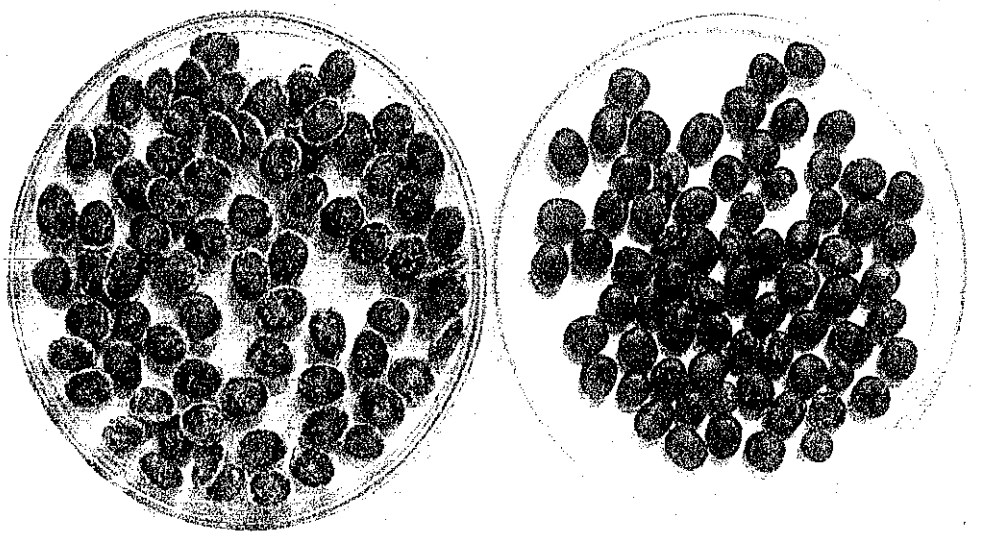


**Plate 4.** 1-2 *A. nilotica* seeds on blotter showing different stages of biodeterioration caused by fungi and bacteria

1. 2.

## 2.4.2. *Albizia lebbeck*

### Seed collection areas

*Albizia lebbeck* is a large deciduous tree sparsely distributed in the dry deciduous (eg. Chinnar) and moist deciduous (eg. Peechi) forests of Kerala. It is cultivated in avenues (Palakkad, Kuzhalmandam and Meenakshipuram and Nilambur) and gardens. Seed trees were identified in two Zones (KL- 2 and 3). The details are given in Table 14.

**Table 14. Details of seed collection areas of *A. lebbeck* in Kerala**

| Seed zone | Sub-zone | Locality | Tree Number | GBH (cm) | Height (m) |
|---|---|---|---|---|---|
| KL-2 | Munnar | Pottithanni | PAI-1 | 167 | 23 |
| | | | PAI-2A1 | 107 | 23 |
| | | | PAI-2A2 | 197 | |
| | | Alampetty | AAI-3 | 68 | 27 |
| | | | AAI-4 | 210 | 07 |
| | | | AAI-5 | 138 | 20 |
| | | | AAI-6A1 | 113 | 19 |
| | | | AAI-6A2 | 100 | |
| | | | AAI-6A3 | 183 | |
| | | | AAI-7 | 163 | 15 |
| | | Karimutty | KAI-8 | 152 | 25 |
| | | | KAI-9 | 116 | 15 |
| | | | KAI-10 | 179 | 12 |
| | | Champakkad | CAI-11A1 | 89 | 11 |
| | | | CAI-11A2 | 64 | |
| | | | CAI-12 | 134 | --- |
| | | | CAI-13 | 145 | 18 |
| | | | CAI-14 | 230 | 29 |
| | | | CAI-15 | 290 | 31 |
| | | Churulipetty | CAI-16 | 116 | 11 |
| | | | CAI-17 | 92 | 20 |
| | | | CAI-18A1 | 118 | 21 |
| | | | CAI-18A2 | 101 | |
| | | | CAI-19 | 94 | 17 |
| | | | CAI-20 | 164 | 21 |
| | Thrissur | KFRI, Peechi | KAI-1 | 325 | 41 |
| KL-3 | Palakkad | Meenakshipuram | MAI-1 | 234 | 16 |
| | | | MAI-2 | 620 | 44 |
| | | Chandra nagar | CAI-1 | 108 | 11 |
| | | Kuzhalmandam | KAI-1 | 186 | 14 |
| | | | KAI-2 | 227 | 23 |
| | | | KAI-3 | 188 | 26 |
| | | | KAI-4 | 165 | 20 |
| | | | KAI-5 | 156 | 14 |
| | | Kottathara | KAI-1 | 130 | 29 |
| | | | KAI-2 | 190 | 14 |
| | | Malampuzha | MAI-1 | 153 | 26 |
| | | | MAI-2 | 165 | 30 |
| | | | MAI-3 | 120 | 20 |
| | | | MAI-4 | 170 | 19 |
| | | | MAI-5 | 181 | 22 |
| | | Kuppadi | KAI-1 | ---- | --- |

KAI-1: KFRI *Albizia lebbeck* number1;KAI-1: Kottathara *Albizia lebbeck* number 1;KAL-1: Kakkupadi *Albizia lebbeck* number 1; KAI-8: Karrimutty *Albizia lebbeck* number 8:KAI-1: Kuzhalmandam *Albizia lebbeck* number 1; MAI-1: Meenakshi puram *Albizia lebbeck* number 1; MAI-1: Malampuzha *Albizia lebbeck* number 1; CAI-1: Chandranagar *Albizia lebbeck* number 1;CAI-11: Chambakkad *Albizia lebbeck* number 11; CAI-17: Churulli petty *Albizia lebbeck* number 17; PAI-1: Pottithanni *Albizia lebbeck* number 1; AAI-3: Alampetty *Albizia lebbeck* number 3; KAI-1: Kuppadi *Albizia lebbeck* number 3; *A1, A2 and A3 refers to the stems of the same tree arising from the base of the tree; --- Height and gbh not measured

The largest tree located at Meenakshipuram had a height 44 m and a girth of 6.2 m for a tree which is much more than an earlier report of 4.52 m mentioned in FRI (1983).

## Phenology of flowering and fruiting

In Kerala, *A. lebbeck* trees flower mainly during January to March (Kuzhalmandam, Kuppadi, Amballur and Peechi). But in Munnar Sub-zone (Champakkad, Churulipetty and Alampetty), Palakkad Sub-zone (Kottathara) and Thrissur Sub-zone (Peechi), flowering was noticed in August and September also. Tree-to-tree variation was observed within the species in flowering and fruit ripening. Pod collection period is from November to March (Kuzhalmandam, Chandranagar, Olamattom and Karimutty) and from February to May (Alampetty, Churulipetty, Karimutty and Kottathara). Details including seed crop status are given in Table 15.

**Table 15. Phenology of flowering and fruiting of *A. lebbeck* in Kerala**

| Seed zone | Sub-zone | Locality | Year | Flowering period | Fruit collection period | Seed crop |
|---|---|---|---|---|---|---|
| KL-2 | Munnar | Olamattom | 1998 | ---- | February | Good |
| | | Champakkad | 1998 | August | February-May | Average |
| | | | | | February | Average |
| | | Churulipetty | 1998 | August | | Poor |
| | | | | | February-May | |
| | | Karimutty | 1998 | August | February-May | Average |
| | | Alampetty | 1998 | August | | Poor |
| | Chalakkudi | Vazhachal | 1998 | Jan-March | March | Poor |
| | | Amballur | 1999 | Jan-March | October | Average |
| | Thrissur | KFRI, Peechi | 1998 | ---- | Feb-May | Poor |
| | | | 1999 | January-March, August | December | Good |
| | | | 2000 | January | Feb-March | Average |
| KL-3 | Palakkad | Kuzhalmandam | 1997 | ---- | November | Good |
| | | | 1998 | March & July-August | December | Good |
| | | | | | July | |
| | | | 1999 | January-March | January-March | Good |
| | | | | ---- | | |
| | | Malampuzha | 1998 | | March | Poor |
| | | | | January-March | | |
| | | Meenakshipuram | 1999 | August | January-March | Average |
| | | Kottathara | 1998 | ----- | March | Good |
| | | | 1999 | September | February | Good |
| | Wayanad | Kuppadi | 1998 | January-February | ----- | ----- |
| | | | 1999 | | ----- | ----- |

--- data not available

## 2.4.3.1. Pod collection and seed extraction

Pods were collected by manual shaking the branches using a long stick with a hook. Of the five different methods of seed extraction (Table 16) best result was obtained for oven-drying of water sprayed pods at 45°C for 24 hours which gave 15.9% complete dehiscence and 52.4% partial dehiscence.

**Table 16. Details of dehiscence of pods dried by different methods**

| Extraction method | % dehiscence | | | MC % of pods |
|---|---|---|---|---|
| | Full | Partial | Total | |
| E1-Drying in the laboratory for 48 h | 6.1 | 29.61 | 35.7 | 8.8 |
| E2-Oven-drying at 35°C for 48 h | 11.4 | 36.4 | 47.8 | 4.9 |
| E3-Oven-drying at 45°C for 48 h | 9.2 | 22.4 | 31.6 | 6.3 |
| E4-Oven-drying of water sprayed pods at 45°C for 48 h | 10.8 | 49.4 | 60.2 | 8.9 |
| E5-Oven-drying of water sprayed pods at 45°C for 24 hours and this process repeated for 24 h | 15.9 | 52.4 | 68.3 | 9.7 |

## 2.4.3.2. Method of extraction and germination

Seed germination was also high in seeds extracted by oven-drying method (Table 17). However it remained unexplained why the germination percentage was low for $H_2SO_4$ treatment and high for boiled water treatment of seeds extracted by oven-drying at 35°C for 2 days.

Seeds could also be extracted from pods using a motorised seed scarifier (Agrosaw sample seed scarifier-electric). But this is inconvenient for the large-scale extraction of seeds. The details regarding germination are given in Table 17.

**Table 17. Effect of different methods of extraction on germination of *A. lebbeck* seeds**

| Extraction method | Germination % at 20 days after sowing, for different treatments | | | Number of days taken for commencing germination | | |
|---|---|---|---|---|---|---|
| | No treatment | $H_2SO_4$ | Boiled water | No treatment | $H_2SO_4$ | Boiled water |
| E1-Drying in the laboratory | 0 | 97 | 66 | --- | 1 | 1 |
| E2-Oven-drying at 35°C for 2 days | 0 | 78 | 71 | --- | 2 | 3 |
| E3-Oven-drying at 45°C for 2 days | 1 | 98 | 65 | 17 | 1 | 2 |
| E4-Oven-drying of water sprayed pods at 45°C for 2 days | 4 | 98 | 63 | 4 | 1 | 1 |
| E5-Oven-drying of water sprayed pods at 45°C for 24 hours and this process repeated for 24 hours (total 48 hours ) | 5 | 99 | 52 | 7 | 1 | 7 |

**Pod characteristics**

Pods are 19 to 22 cm long (Plate 5), 4 to 5 cm wide, and 300 to 500 pods weigh a kilogram. One kg pods give 1000 to 3200 seeds. Maximum number of seeds was obtained from pods collected from Kuzhalmandam (3212/Kg seeds). The details are given in Table 18.

**Table 18. Pod characteristics of *A. lebbeck***

| Locality | Seed zone | Sub-zone | Mean seed measurements (cm) | | Mean No. of pods/kg | Mean No. of seeds/kg pod (g) |
|---|---|---|---|---|---|---|
| | | | Length | Width | | |
| Olamattom | KL-2 | Munnar | 19 | 4 | 504 | 1076 |
| Karimutty | ,, | ,, | 21 | 5 | 317 | 1274 |
| Churulipetty | ,, | ,, | 17 | 4 | 433 | 2615 |
| Chandranagar | KL-3 | Palakkad | 22 | 5 | 317 | 2107 |
| Kuzhalmandam | ,, | ,, | 19 | 5 | --- | 3212 |

--- data not available

**Seed characteristics**

There is considerable variation in seed length, width and 1000 seed weight collected from different localities (Plate, 6). Seed length varies from 0.6 cm to 1.1 cm, width varies from 0.61 to 0.78 cm, thickness varies from 0.20 to 0.24 cm. Weight of 1000 seeds varies from 97 to 147g. Details are given in Table 19a.

**Table 19a. Seed characteristics of *A. lebbeck***

| Locality | Seed zone | Sub-zone | Mean seed measurements (cm) | | | 1000 seed weight (g) |
|---|---|---|---|---|---|---|
| | | | Length | Width | Thickness | |
| Kuzhalmandam | KL-3 | Palakkad | 0.91 | 0.64 | 0.22 | 113.5 |
| Chandranagar | ,, | ,, | 1.10 | 0.66 | 0.22 | 132.8 |
| Karimutty | KL-2 | Munnar | 1.10 | 0.67 | 0.21 | 143.1 |
| Churulipetty | ,, | ,, | 0.62 | 0.66 | 0.24 | 147.2 |
| Pottithanni | ,, | ,, | 0.86 | 0.70 | 0.20 | 97.50 |
| Champakkad | ,, | ,, | 0.91 | 0.67 | 0.21 | 122.8 |
| Alampetty | ,, | ,, | 0.95 | 0.78 | 0.20 | --- |

--- data not available

Percentage of sound seeds varies from 23 to 60. Considerable variation in seed size and weight is reflected in the number of seeds per kg (6,250 to 12,210) and also the number of seeds per litre (4,200 to 10,000). Details are given in Table 19b. Hocking (1993) reported number of seeds/kg varies 7,000 to 12,000 while Lowry *et al.* (1994) reported 7000 to 8000 seeds/kg (CABI, 1998).

**Table 19b. Seed characteristics of *A. lebbeck***

| Locality | Seeds/kg | Seeds/litre | % of sound seeds in a sample | MC% of seed | Days elapsed between collection and MC% determination |
|---|---|---|---|---|---|
| Olamattom | 8,965 | 7,640 | 53.2 | 12.68 | 19 |
| Karimutty | 8,670 | 5,961 | 30.3 | -- | 8 |
| Churulipetty | 12,218 | 10,106 | 23.2 | 12.24 | 8 |
| Chandranagar | 6,251 | 4,258 | 36.2 | 7.73 | 21 |
| Kuzhalmandam | 10,464 | 8,720 | 59.9 | 4.79 | 21 |

-- data not available

**Table 20. Seed/fruit characteristics of *A. lebbeck* collected from different localities in the State**

| Seed/fruit characteristics | Localities | | |
|---|---|---|---|
| | Chinnar | Kuzhalmandam | Palakkad |
| Length of pod (cm) | 19.76 | 23.75 | 21.72 |
| Width of pod (cm) | 3.79 | 4.53 | 4.08 |
| No. of locules per pod | 6.50 | 11.80 | 9.00 |
| No. of seeds per pod | 6.00 | 10.60 | 8.40 |
| % discoloured and deformed seeds | 50.00 | 52.00 | 60.00 |
| Weight of 100 seeds (g) | 12.00 | 11.20 | 11.90 |
| Weight of 100 discoloured seeds (g) | 5.79 | 9.50 | 9.80 |

## 2.4.3.3. Pre-sowing treatment and germination

**Test No. 1:** Sulphuric acid treated seeds gave maximum germination (100%), followed by mechanical scarification (23%). Untreated seeds (control) gave only 2% germination. The details are given in Table 21.

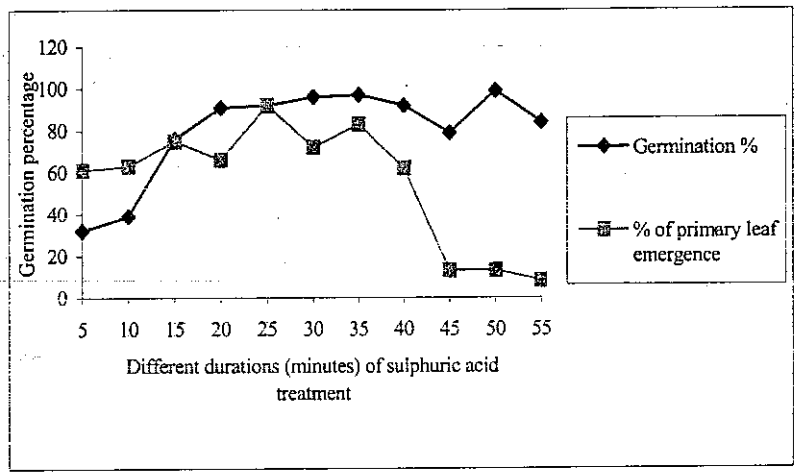
**Table 21. Effect of pre-sowing treatment on germination of *A. lebbeck* seeds**

| Pre-sowing treatment | % germination at 20 days after sowing | Number of days taken for commencement of germination |
|---|---|---|
| T1. $H_2SO_4$ (30 minutes) | 100 | 2 |
| T2. Hot water (5-10 minutes) | 7 | 12 |
| T3. Mechanical scarification | 23 | 2 |
| T4. Control | 2 | 5 |

**Test No. 2:** For sulphuric acid treatment, 35 minutes was the best duration. Seed germination occurred (92%) within 7 days after sowing and all the emerged seedlings produced first pair of leaves within 25 days. Acid treatment for 50, 55 and 60 minutes gave faster germination but germinants decayed after 2 or 3 days. Even though, primary leaves appeared in some seedlings, they were found curled. Moreover, primary roots were not produced; instead, lateral roots were formed at

the base of the shoot system. The details regarding germination and emergence of primary leaf are given in Figure 7.

**Figure 7. Effect of pre-sowing treatments on germination and emergence of primary leaf in *A. lebbeck***




## 2.4.3.4. Effect of source and pre-sowing treatments on germination

**Test Nos. 1 and 2:** There is considerable variation in germination of seeds collected from the same Sub-zones. Seeds collected from Chandranagar and Kuzhalmandam belonging to the Sub-zone Palakkad gave 100% and 89% germination respectively for sulphuric acid treatment, and 95% and 84% respectively for boiling water treatment. Similarly, seed source of Olamattom, Pottithanni, Churulipetty and Champakkkad belonging to the same Sub-zone Munnar gave 100%, 88%, 97% and 64% germination respectively for sulphuric acid treatment and 95%, 22%, 58% and 30% respectively for boiled water treatment (Table 22).

**Table 22. Germination of *A. lebbeck* seeds after different pre-sowing treatments**

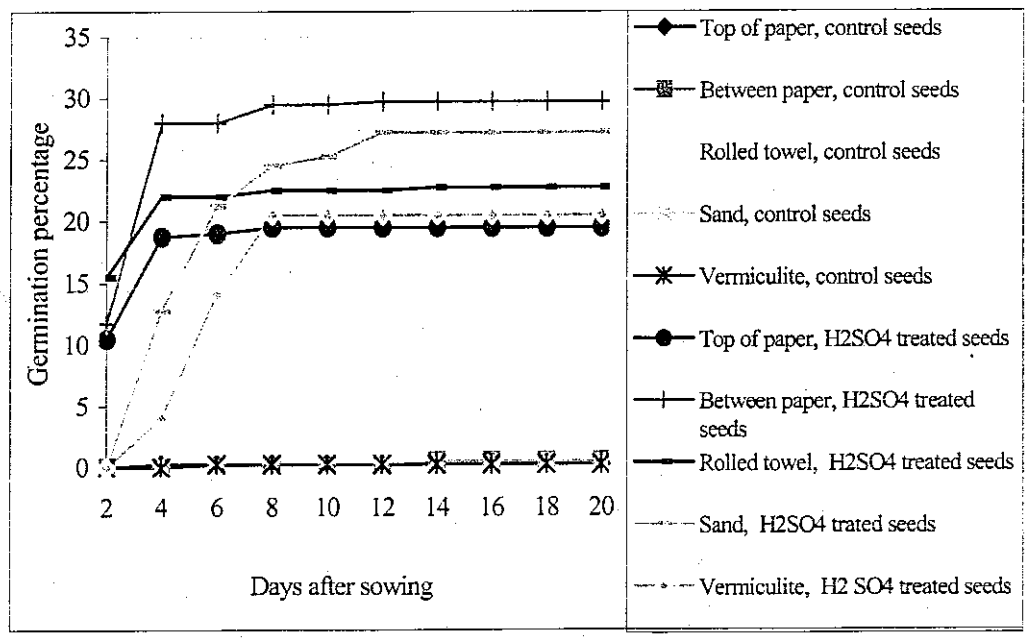
| Locality | Date of collection | MC% of seed | Germination% at 15 days after sowing | |
|---|---|---|---|---|
| | | | $H_2SO_4$ | Boiled water |
| Olamattom | 04/02/98 | 21.3 | 100 | 95 |
| Pottithanni | 17/02/98 | 23.0 | 88 | -- |
| Churulipetty | 27/05/98 | 21.2 | 97 | 58 |
| Champakkad | 31/08/97 | 27.9 | 64 | 30 |
| Chandranagar | 17/02/98 | 15.4 | 89 | 95 |
| Kuzhalmandam | 26/05/98 | 9.45 | 100 | 84 |

--- indicates data not available

## 2.4.3.5. Media and germination

Of the five media tried, between moist germination papers gave maximum germination (29.8%), followed by quartz sand (27.3%), Vermiculite (20.8%) and Rolled towel (19.8%). Germination was poor in top of paper (2.5%). Details of germination are given in Figure 8.

**Figure 8. Effect of media on germination of *A. lebbeck* seeds**



## 2.4.3.6. Effect of seed source

There was considerable variation in germination of seeds collected from different sources. The percent germination varied from 35 to 96 (Table 23). Considering all the seed sources, source 10 and 11 (Meenakshipuram, MAl-1 and MAl-2) gave maximum germination occurred within 4-10 days.

**Table 23. Germination of *A. lebbeck* seeds from different sources**

| Source | MC% of seed | % cumulative germination at 20 days after sowing | | Number of days taken for commencing germination | |
|---|---|---|---|---|---|
| | | Rolled towel | Quartz sand | Rolled towel | Quartz sand |
| S1 (Kuzhalmandam- KAl-1) | 12.19 | 94 | 73 | 5 | 4 |
| S2 (Kuzhalmandam -KAl-3a) | 15.60 | 83 | 63 | 7 | 4 |
| S3 (Kuzhalmandam- KAl-3b) | 16.28 | 35 | 07 | 8 | 5 |
| S4 (Kuzhalmandam KAl-4) | 13.24 | 87 | 27 | 7 | 5 |
| S5 (Karimutty -KAl-10) | 14.56 | 85 | 66 | 7 | 3 |
| S6 (Champakkad-CAl-14) | 14.41 | 74 | 65 | 7 | 4 |
| S7 (Pottithanni- PAl-1) | 12.94 | 86 | 83 | 7 | 4 |
| S8 (Kottathara- KAl-1) | 12.64 | 79 | 56 | 8 | 6 |
| S9 (Kottathara- KAl-2) | 13.38 | 83 | 58 | 5 | -- |
| S10 (Meenakshipuram MAl-1) | 13.08 | 96 | 86 | 4 | 4 |
| S11 (Meenakshipuram MAl-2) | 11.00 | 95 | 86 | 4 | 4 |

--- indicates data not available

## 2.4.3.7. Light and germination

**Table 24. Details regarding light conditions provided for the experiment**

| Type of covering | Quantity of Photosynthetically Active Radiation (micromole /$m^2$/s) | | |
|---|---|---|---|
| | Laboratory | Nursery shed | Open ground |
| Nil | 8 | 216 | 1619 |
| Transparent sheet | 6 | 197 | 1535 |
| Translucent sheet | 4 | 138 | 1095 |
| Black polythene sheet | 0 | 0 | 0 |

Light is not essential for germination of *A. lebbeck* seeds. Full light gave slightly better germination for both treated (light) and untreated seeds. Seeds pre-treated with $H_2SO_4$ from both the sources gave maximum germination irrespective of light intensity. In source 1, (Kuzhalmandam KAl-1) germination percentage of pre-treated seeds was 57.25, 67.5 and 72.75 for full, partial and no light conditions

respectively. In source 2 (Kuzhalmandam KAI-3a), germination was 76.5%, 77.5%, 80%, under full, partial and no light conditions respectively. However, Seedlings in no light condition were yellow in colour and when exposed to light, developed chlorophyll. Details of germination are given in Figure 9(a) and 9(b).

**Figure 9(a). Effect of light on germination of seeds from source-1**

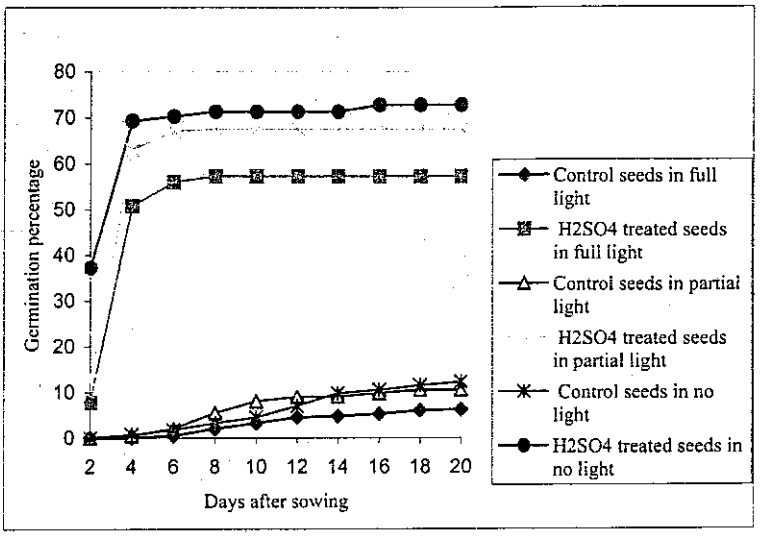
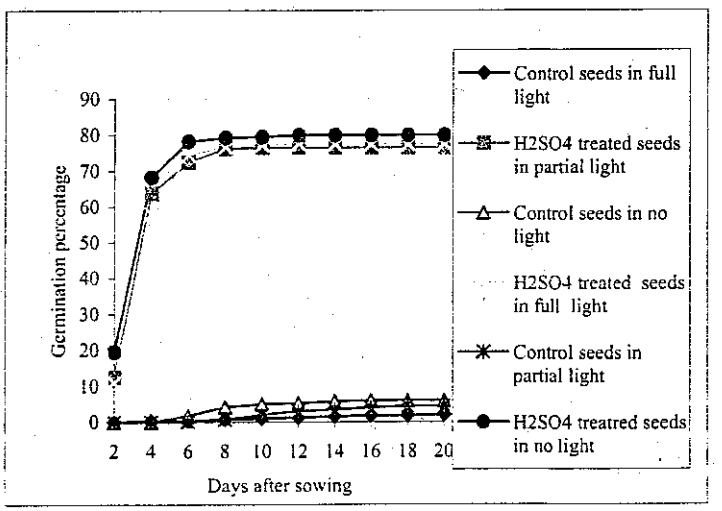



**Figure 9(b). Effect of light on germination of seeds from source-2**



## 2.4.3.8. Seed pathology of *A. lebbeck*

**Dry seed examination**

*A. lebbeck* seeds collected from the three localities viz., Chinnar, Kuzhalmandam and Palakkad were severely affected with microorganisms. The percentage of discoloured and deformed seeds was very high and it ranged from 50 to 60 (Table 20). The fruit characteristics viz., length and width of pod, number of locules per pod, number of seeds per pod, etc. varied considerably (Table 20). Percent moisture content of seeds collected from different localities ranged from 10.62 to 12.15. Severe infection of seeds inside the pod as well as germination of intact seeds was also noticed (Plate 7). The weight of 100 seeds from the pooled samples from the three localities ranged from 11.2 to 12.0 g. Dry seed examination revealed fungal mycelial mats, fructifications, as well as insect infestations. Comparatively, deformed, shriveled, and infested seeds were high in seedlot from Chinnar than those from other two localities.

**Seed microflora**

A rich microflora comprising of 19 fungal genera, together with unidentified mycelia sterilia, bacteria and actinomycetes were encountered on seeds of *A. lebbeck* collected from the three different agroclimatic sub-zones of the State (Tables 25-28). Seed health test by blotter method revealed a large number of spermoplane microbes on non-surface sterilized seeds (Plate 8). Among the seedlots tested, those from Palakkad recorded more number of spermoplane microbes, which include common storage moulds, field fungi, bacteria and actinomycetes. Among the storage moulds, *Aspergillus spp., Chaetomium* sp., *Rhizopus* sp., *Penicllium* sp., etc. were the predominant fungi. Their frequency of occurrence ranged from 21-48%. Among the field fungi recorded on seeds, *Beltrania* sp., *Colletotrichum gloeosporioides*, *Fusarium* sp. and *Phoma* sp. are the important ones and their percent incidence in the seed samples from the three localities ranged from 7 to 21. Seeds from Chinnar recorded the least number and percent incidence of field fungi, while the seeds from Palakkad yielded more number of field fungi as well as their percent incidence. Incidence of bacteria in seeds ranged from 7 to 19% in non-surface sterilized seed samples. Bacteria were

found mostly associated with the discoloured and deformed seeds and such seeds become completely rotten with heavy bacterial ooze. Though surface sterilizaiton with 0.01% mercuric chloride reduced the percent incidence of the bacteria, both hot water and acid treatment increased the percent incidence. A high percent (32) incidence of bacteria was recorded in hot water treatment of seedlots from Chinnar and Kuzhalmandam. However, in general, hot water and acid treatments to break the seed dormancy and to enhance the seed germination also reduced the number of spermoplane fungi and their intensity.

**Growing-on test**

Seeds from Palakkad were used for the growing-on test. Emergence of seedlings started 4 to 5 days after sowing in sterile perlite medium and continued up to 9 days. Most seedlings emerged within 5 to 7 days of sowing. Percentage germination (73%) was found lower than that obtained by blotter method. Seedling infection viz., cotyledon infection (bacterial), rots of radicle and plumule (bacterial) and leaf spot caused by *Fusarium* sp. and *Colletotrichum gloeosporioides* were observed.

**Seed pre-treatment**

Seed pre-treatments viz., hot water soaking and conc. sulphuric acid treatment (5 min) to break the seed dormancy and to enhance the germinability indicate that both the treatments were equally effective (Table 28). In hot water treatment, seedlot from Palakkad gave higher percent germination (92), while seedlot from Kuzhalmandam recorded only 60% germination. Seedlots from all the three localities gave high percent germination in acid treatment that ranged from 94-95% (Table 28). The results indicate that acid treatment has to be carried out to get a maximum percent germination of *A. lebbeck* seeds.

**Table 25. Microorganisms detected on seeds of *A. lebbeck* (Kuzhalmandam 1998 seedlot) by blotter method and their percent incidence**

| Sl. No. | Microorganisms | Blotter method % incidence | | | |
|---|---|---|---|---|---|
| | | NSS | SS | HW | A |
| 1 | *Aspergillus* spp. | 10.00 | 5.00 | 13.00 | 7.00 |
| 2 | *Aspergillus niger* | 00.50 | | | |
| 3 | *Beltrania* sp. | 08.00 | 8.00 | 12.00 | |
| 4 | *Chaetomium* sp. | 02.00 | 4.00 | 1.00 | 3.00 |
| 5 | *Colletotrichum gloeosporioides* | 00.50 | | | |
| 6 | *Fusarium* sp. | 01.00 | 4.00 | | |
| 7 | *Paecilomyces* sp. | 00.75 | | 1.00 | |
| 8 | *Penicillium* sp. | 16.00 | 3.00 | 6.00 | |
| 9 | *Rhizopus* sp. | 02.25 | 2.00 | | |
| 10 | *Trichoderma* sp. | | 2.00 | 2.50 | 3.00 |
| 11 | Sterile mycelium (black) | 00.5 | 1.50 | 1.00 | |
| 12 | Sterile mycelium (white) | 01.00 | 0.50 | | 2.00 |
| 13 | Bacteria | 17.00 | 11.00 | 32.00 | 4.00 |
| 14 | Actinomycetes | 05.50 | 1.00 | | 3.00 |

*NSS: non-surface sterilized; SS: surface sterilized; HW: hot water treatment; A: sulphuric acid treatment

**Table 26. Spermoplane microorganisms detected on seeds of *A. lebbeck* (Chinnar 1998 seedlot) by blotter and agar methods and their percent incidence**

| Sl. No. | Microorganisms | Blotter method %incidence | | | | Agar plate method % incidence |
|---|---|---|---|---|---|---|
| | | NSS | SS | HW | A | |
| 1 | *Aspergillus* spp. | 11.50 | 4.00 | 7.00 | 17.00 | |
| 2 | *Aspergillus flavus* | 02.00 | 1.00 | | 1.00 | |
| 3 | *Aspergillus niger* | 11.50 | 2.00 | 10.00 | 14.00 | |
| 4 | *Beltrania* sp. | 03.00 | 1.00 | | | 0.66 |
| 5 | *Chaetomium gloeosporioides.* | 07.00 | 4.00 | 3.00 | | |
| 6 | *Colletotrichum* sp. | | | | | 1.33 |
| 7 | *Curvularia* sp. | | | | | 3.33 |
| 8 | *Fusarium* sp. | 04.00 | | | | 8.00 |
| 9 | *Penicillium* sp. | 06.00 | 1.00 | 6.00 | 6.00 | 5.00 |
| 10 | *Trichoderma* sp. | 07.00 | 3.00 | 2.00 | 3.00 | |
| 11 | Sterile mycelium (black) | | | 2.00 | | 1.33 |
| 12 | Sterile mycelium (White) | | | | 10.00 | |
| 13 | Bacteria | 17.00 | 6.00 | 32.00 | 34.00 | 7.33 |
| 14 | Actinomycetes | 04.00 | 2.00 | | | 2.00 |

*NSS: non-surface sterilized; SS: surface sterilized; HW: hot water treatment; A: sulphuric acid treatment

**Table 27. Spermoplane microorganisms detected on seeds of *Albizia lebbeck* (Palakkad 1998 seedlot) by blotter and agar plate methods and their percent incidence**

| Sl. No. | Microorganisms | Blotter method % incidence | | | | Agar Plate Method % incidence |
|---|---|---|---|---|---|---|
| | | NSS | SS | HW | A | |
| 1 | *Alternaria* sp. | 0.50 | | | | |
| 2 | *Aspergillus* spp. | 2.00 | 1.00 | 1.00 | | |
| 3 | *Aspergillus flavus* | 0.50 | | | | |
| 4 | *Beltrania* sp. | 1.00 | | | | 1.00 |
| 5 | *Aspergillus niger* | 7.00 | 5.00 | 2.00 | 1.00 | 8.00 |
| 6 | *Bipolaris* sp. | 0.50 | | | | |
| 7 | *Cephalosporium* sp. | 1.00 | | | | |
| 8 | *Chaetomium* sp. | 3.00 | 2.00 | 2.00 | | |
| 9 | *Colletotrichum gloeosporioides* | 4.25 | | | | 2.00 |
| 10 | *Curvularia sp.* | 10.00 | | | | |
| 11 | *Drechslera* sp. | 1.50 | | | | |
| 12 | *Fusarium* sp. | 1.25 | 1.00 | | | 4.00 |
| 13 | *Mucor* sp. | 1.00 | | | | |
| 14 | *Paecilomyces* sp. | 1.50 | | | | |
| 15 | *Penicillium* sp. | 2.50 | | | 2.00 | |
| 16 | *Phoma* sp. | 2.00 | | | | |
| 17 | *Trichoderma* sp. | 2.25 | 2.00 | 2.00 | | |
| 18 | *Verticillium* sp. | 1.00 | | | | |
| 19 | Sterile mycelium (White) | 2.50 | 1.00 | | 5.00 | 2.00 |
| 20 | Sterile mycelium (Black) | 1.00 | | | 5.00 | 2.00 |
| 21 | Bacteria | 7.00 | 6.00 | 8.00 | 6.00 | 8.00 |
| 22 | Actinomyctes | 4.00 | 3.00 | 3.00 | | |

*NSS: non-surface sterilized; SS: surface sterilized; HW: hot water treatment; A: sulphuric acid treatment

**Table 28. Effect of various treatments on germination of seeds of *A. lebbeck* collected from different localities of the state**

| Locality | Zone | Sub Zone | Percent germination | | | |
|---|---|---|---|---|---|---|
| | | | NSS | SS | HW | A |
| Kuzhalmandam | KL-3 | Palakkad | 07.50 | 34.50 | 60.00 | 94.00 |
| Palakkad | KL-3 | Palakkad | 60.00 | 51.50 | 92.00 | 95.00 |
| Chinnar | KL-2 | Munnar | 26.50 | 63.00 | 80.00 | 94.00 |

*NSS:non-surface sterilized; SS: surface sterilized; HW: hot water treatment; A: acid treatment

**Plate 5. Pods of *A. lebbeck***

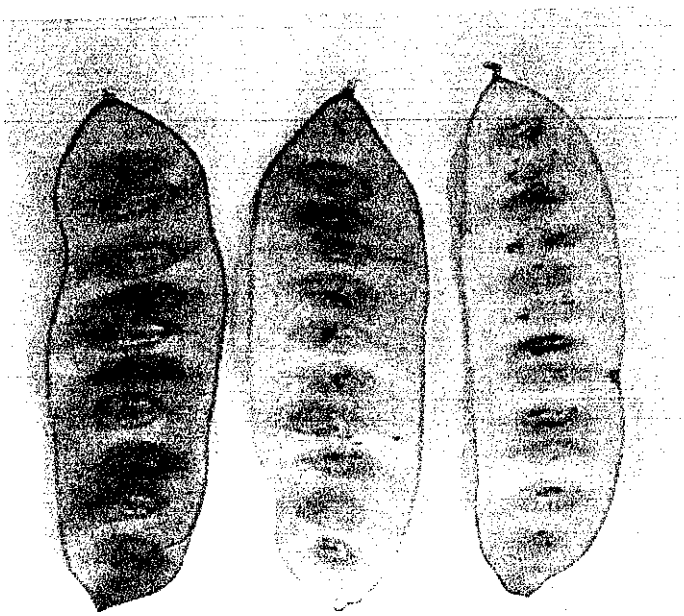
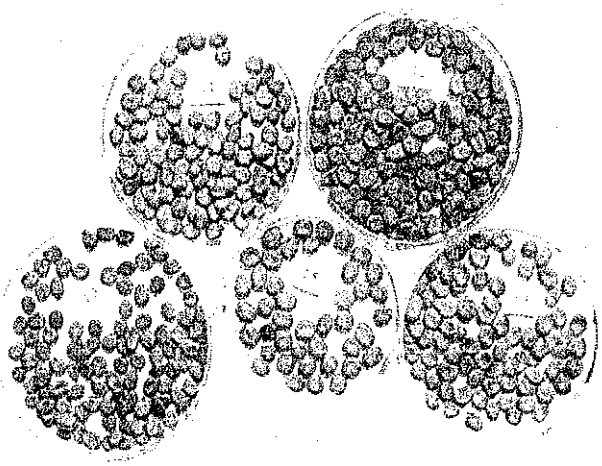


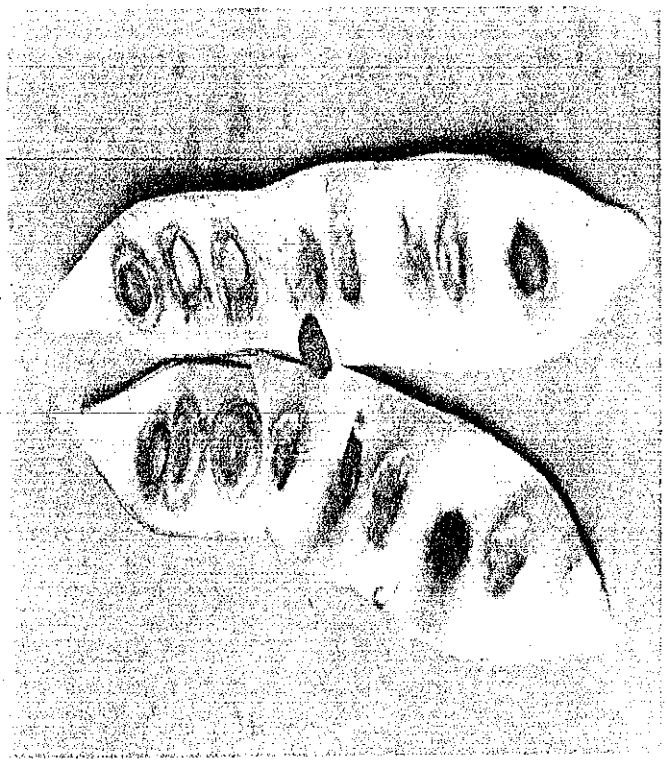
**Plate 6. *A. lebbeck* seeds collected from different localities**



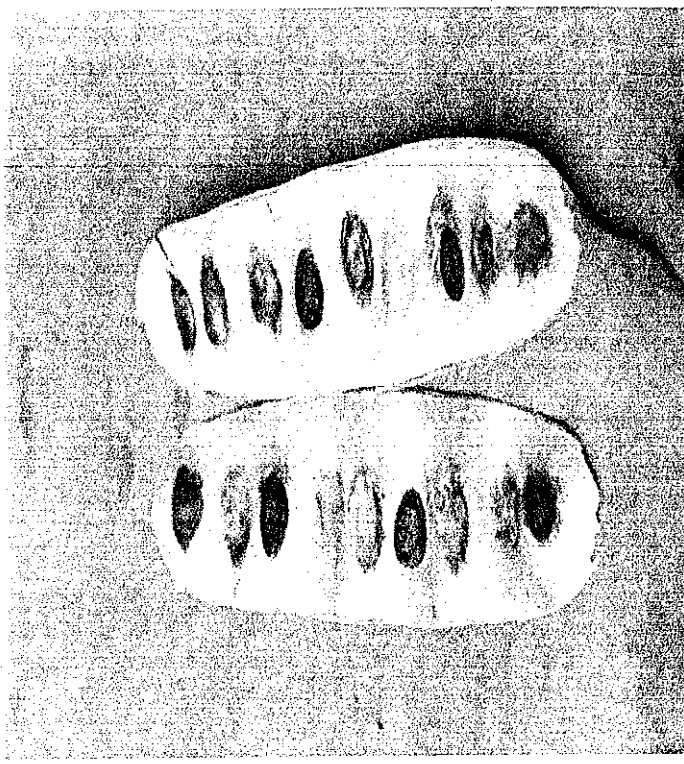
L1: Meenakshipuram, MAl-2 (*Albizia lebbeck* tree number 2);L2: Kuzhalmandam KAl-3; L3: Champakkad CAl-14;L4: Kuzhalmandam KAl-4; L5: Kottathara KAl-2

**Plate 7. 1-2 *A. lebbeck* mature open pods showing intact seeds at various stages of biodeterioration; 3-4 pod with germinating seed**

1.



2.



3.

4.

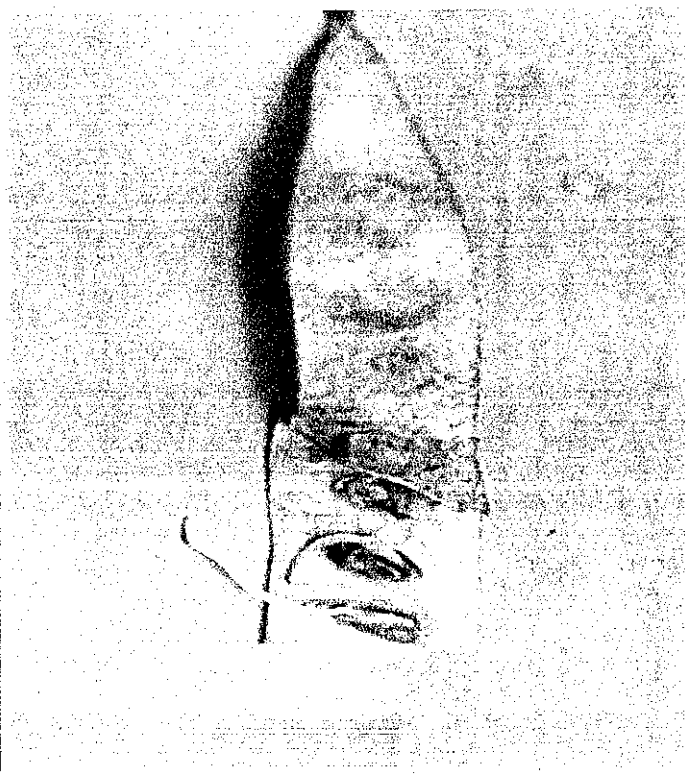
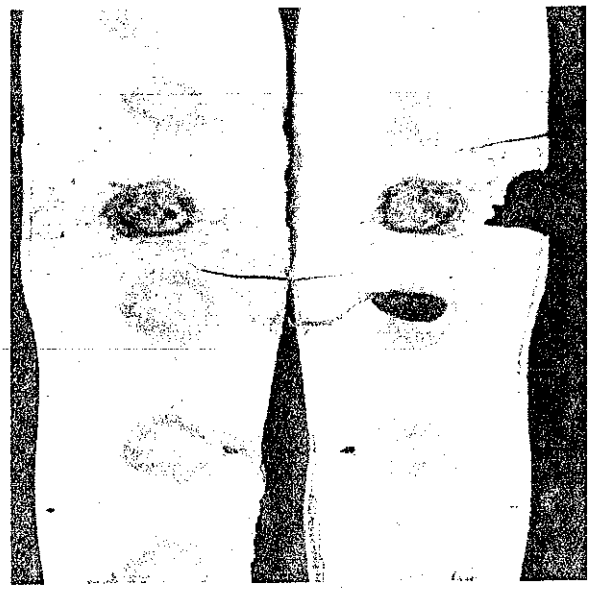
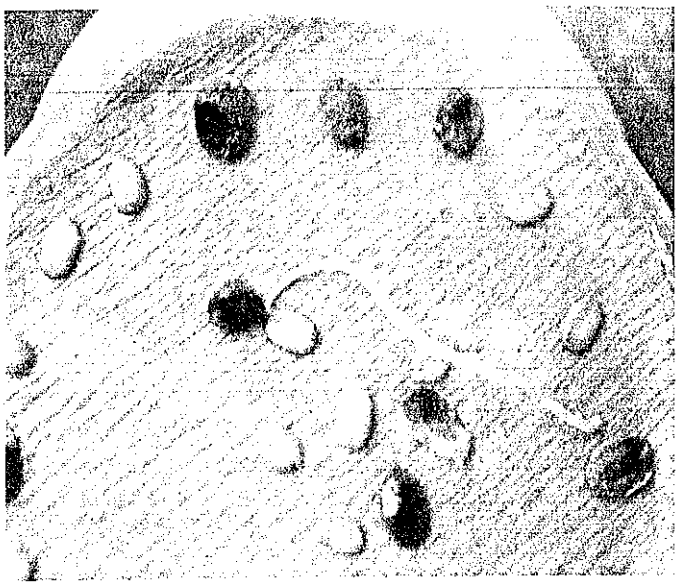


**Plate 8. 1. *A. lebbeck* mature dried pod with discoloured and deteriorated seeds and also a germinating seed; 2, *A. lebbeck* seeds on blotter**





## 2.4.3. *Dalbergia sissoides*

### Seed collection areas

*D. sissoides* is a medium sized deciduous tree found in the moist deciduous forests of Kerala especially in very moist teak forests (Karulai and Dhoni), and mixed deciduous forests (Sholayur, Chinnar and Kuppadi). The seed trees were identified in all the three zones (KL-1, KL-2 and KL-3). The details are given in Table 29. The maximum tree height (37 m) was recorded for a tree at Dhoni and maximum gbh (2.72m) was measured for a tree at Mundakkadavu.

**Table 29. Seed collection areas of *Dalbergia sissoides* in Kerala**

| Seed zone | Sub-zone | Locality | Tree No. | GBH (cm) | Height (m) |
|---|---|---|---|---|---|
| KL-1 | Kottayam | Ezhukumannu | EDs-1 | --- | --- |
| | | | EDs-2 | 87 | 20 |
| KL-2 | Malayattur | Malayattur | MDs-1 | 205 | 31 |
| | Thrissur | KFRI, Peechi | KDs-1 | 175 | 21 |
| | | | KDs-2 | --- | --- |
| | | | KDs-3 | 262 | 24 |
| | Chalakkudi | Vettingapadam | VDs-1 | 74 | 23 |
| | | | VDs-2 | 125 | 18 |
| | | | VDs-3 | 144 | 17 |
| | | | VDs-4 | 159 | 19 |
| | | | VDs-5 | 192 | 20 |
| | Munnar | Karimutty | KDs-1 | 259 | 30 |
| | | Champakkad | CDs-2 | 48 | 15 |
| | | Churulipetty | CDs-3 | 164 | 21 |
| | | | CDs-4 | 87 | 17 |
| KL-3 | Palakkad | Kuthiran | KDs-1 | 171 | 29 |
| | | | KDs-2 | 126 | 28 |
| | | Dhoni | PDs-1 | 134 | 24 |
| | | | PDs-2 | 208 | 13 |
| | | | PDs-3 | 260 | 37 |
| | | Kakkupadi | KDs-1 | 110 | 14 |
| | | | KDs-2 | 168 | 15 |
| | | | KDs-3 | 145 | 16 |
| | | | KDs-4 | 132 | 14 |
| | | | KDs-5 | 196 | 21 |
| | | | KDs-6 | --- | --- |
| | | | KDs-7 | 189 | 23 |
| | | Thavalam | TDs-8 | 225 | 23 |
| | | | TDs-9 | 227 | 23 |
| | | Pakkulam | PDs-10 | 243 | 33 |
| | | | PDs-11 | 67 | 12 |
| | | | PDs-12 | 234 | 31 |
| | | | PDs-13 | --- | --- |
| | | | PDs-14 | --- | --- |
| | | | PDs-15 | --- | --- |
| | | | PDs-16 | 108 | 15 |
| | | Agali | ADs-17 | 185 | 24 |
| | | | ADs-18 | 180 | 18 |

| | | | | | |
|---|---|---|---|---|---|
| | Nilambur | Nellikkuthu Mundakkdavu | NDs-1 | 98 | 20 |
| | | | MDs-2 | 86 | 15 |
| | | | MDs-3 | 85 | 20 |
| | | | MDs-4 | 178 | 18 |
| | | | MDs-5 | 107 | 16 |
| | | | MDs-6 | 97 | 14 |
| | | | MDs-7 | 272 | 30 |
| | | | MDs-8 | 130 | 17 |
| | | | MDs-9 | 166 | 30 |

--- data not available

KDs-1: Kuthiran *Dalbergia sissoides* number 1; PDs-1: Puzhamgundu *Dhoni Dalbergia* sissoides number 1; EDs-1: Ezhukumannu *Dalbergia sissoides* number1; MDs-1:Malayattur *Dalbergia sissoides* number 1; CDs-2:Champakkad *Dalbergia sissoides* number 2; CDs-3:Churulipetty *Dalbergia sissoides* number 3

## Phenology of flowering and fruiting

The tree is in flower during December to January in Peechi and up to February in Kuppadi and Dhoni. Seeds are available for collection in February. At Champakkad, mature fruits were available during April. Details are given in Table30.

**Table 30. Phenology of flowering period and fruit collection period of *D. sissoides* in Kerala**

| Zone | Sub-zone | Locality | Year | Flowering period | Fruit collection period | Seed crop |
|---|---|---|---|---|---|---|
| KL-2 | Munnar | champakkad | 1998 | ---- | April | Average |
| | | | 1999 | ---- | Nil | Nil |
| | Malayattur | Malayattur | 1998 | Nil | Nil | Nil |
| | | | 1999 | Nil | Nil | Nil |
| | Chalakkudi | vazhachal | 1998 | Nil | Nil | Nil |
| | | Vettingapadam | 1998 | Nil | Nil | Nil |
| | Thrissur | KFRI, Peechi | 1998 | Nil | Nil | Nil |
| | | | 1999 | January | Nil | Nil |
| | | Kuthiran | 1998 | Nil | Nil | Nil |
| | | | 1999 | Nil | Nil | Nil |
| KL-3 | Palakkad | Kakkupadi | 1998 | January-March | January-March | Poor |
| | | | 1999 | | | |
| | | Sholayur | 1999 | ---- | February | Average |
| | | Dhoni | 1998 | ---- | Nil | Nil |
| | | | 1999 | January | February | Good |
| | Nilambur | Nedungayam | 1998 | Nil | Nil | Nil |
| | | | 1999 | Nil | Nil | Nil |
| | Wayanad | Ondayangadi | 1999 | January-February | February | Good |

--- data not available.

### 2.4.3.1. Pod collection and seed extraction

Pods (Plate 9) were collected when they were light brown in colour. Collection was made by lopping off the branches. Pods, being light in weight, should be collected early in the morning, especially to overcome the possibility of

their getting blown away. It is essential to clear the ground before lopping off the branches. Plastic sheets spread around the tree made the collection easier.

**Test No. 1:** None of the pod drying methods including sun-dry and oven-dry could dehisce the pods, since the pods are naturally indehiscent.

**Test No. 2:** Pods when dried by oven-drying at 45°C for two days (T3) became brittle for extraction using a seed scarifier. Pods oven-dried at 50°C took three hours to become brittle. This was the lowest time required for the pods to become brittle at this temperature.

**Seed extraction using a metal grating:** Rubbing on a metal grating helped the release of only 25% of seeds in both the drying methods.

**Seed extraction using a motorised seed scarifier (electric):**

As the pods were dry soon after collection, seeds could be extracted using seed scarifier without oven-drying the pods. In this method about 95% seeds were released. The results are given in Table 31.

**Table 31. Mean seed yield from freshly collected pods of *D. sissoides***

| Locality | Seed yield weight (%) | Number of sound seeds per kg. of pods | % of sound seeds | % of damaged seeds | % of unreleased seeds |
|---|---|---|---|---|---|
| Panthanthode | 33<br>(1) | 15180<br>(860) | 96<br>(2) | 3<br>(2) | 1<br>(1) |
| Peruvaripallam | 21<br>(1) | 5530<br>(720) | 88<br>(9) | 9<br>(1) | 3<br>(0.2) |
| Sholayur | 26<br>(6) | 10810<br>(2260) | 84<br>(6) | 5<br>(2) | 11<br>(7) |
| Pooled Mean | 26.67<br>(6.02) | 10507<br>(4832) | 89.33<br>(6.11) | 5.67<br>(3.06) | 5.33<br>(4.93) |

*The figures in parenthesis indicates S.E of mean value

If the seeds are not dry during collection, the pods can be oven-dried and seeds extracted using seed scarifier. About 89% of seeds can be extracted by a seed scarifier by this method. The results of seed extraction by oven-drying is given in Table 32.

**Table 32. Details of seed extraction of *D. sissoides* by oven-drying**

| Locality | Tree number | Fresh pod weight (g) | Oven-dry pod weight(g) | Number of seeds | % of sound seeds | % of damaged seeds | % of unreleased seeds |
|---|---|---|---|---|---|---|---|
| Panthanthode | PDs 2 and PDs 3 | 275 | 269 | 3231.00 | 82.6 | 2.6 | 15.00 |
| „ | PDs-2 | 215.00 | 214.00 | 2588.00 | 80.3 | 3.5 | 16.00 |
| „ | PDs-1 | 232.00 | 229.00 | 2830.00 | 96.2 | 1.9 | 2.00 |
| Peruvaripallam | PDs-2 | 295.00 | 292.00 | 3626.00 | 82.6 | 3.6 | 10.00 |
| Sholayur | SDs-1 | 322.00 | 314.00 | 3089.00 | 83.1 | 4.7 | 13.00 |
| Mean | | 267.80 | 263.60 | 3072.80 | 85.0 | 3.3 | 11.20 |

## Methods of extraction and seed purity

Seed purity was higher when the seeds were extracted by a seed scarifier than a metal grating. Details are given in Table 33.

**Table 33. Purity of *D. sissoides* seeds extracted by different methods**

| Method of extraction | Purity % |
|---|---|
| Rubbing on a metal grating | 85.12 (2.474) |
| Seed scarifier | 96.847 (1.29) |

(Figures in parenthesis indicates S.E. of mean value).

### Pod characteristics

Pod length, width, thickness and number of seeds per pod do not vary much between localities but there is considerable variation in number of pods per kg. In general, pod length varies from 3 to 10 cm; width, from 1 to 2 cm; thickness, from 0.1 to 0.2 cm; number of seeds (Plate 10) per pod, from 1 to 6 mm; and number of pods per kg from 5200 to 10100. Details are given in Table 34.

**Table 34. Pod characteristics of *D. sissoides***

| Locality | Tree number | Pod Length (cm) | Pod Width (cm) | Pod thickness (cm) | Number of seeds per pod | Number of pods per kg |
|---|---|---|---|---|---|---|
| | | Range | Range | Range | Range | Range |
| Panthanthode | PDs-2 & PDs-3 | 3-8.5 (5.08) | 1-1.3 (1.08) | 0.1-0.16 (0.13) | 1-5 (2.25) | 8800-9500 (9183) |
| ,, | PDs-2 | 4-7.8 (6.08) | 1-1.3 (1.11) | 0.1-0.15 (0.12) | 1-5 (2.46) | 7800-8500 (8188) |
| ,, | PDs-1 | 3.5-9 (6.07) | 1-1.5 (1.13) | 0.1-0.2 (0.10) | 1-6 (3.44) | 7500-8200 (7890) |
| Peruvaripallam | PDs-2 | 4-10 (7.3) | 1.1-1.6 (1.47) | 0.1-0.18 (0.13) | 1-5 (2.62) | 5200-6100 (5730) |
| Sholayur | SDs-1 | 4-9 (5.93) | 1-1.9 (1.22) | 0.1-0.15 (0.12) | 1-5 (2.86) | 8600-10100 (9389) |
| Pooled mean | | 6.09 *(0.70) | 1.203 *(0.14) | 0.12 *(0.01) | 2.728 *(0.40) | 8062 *(627) |

Figures in parenthesis indicates mean value
* figures indicates S.E. of pooled mean

## Seed characteristics

There is considerable variation in weight of 1000 seeds, seeds per litre, seeds per kg between localities. . In general, seed length varies from 5 to 7 mm; width, from 3 to 5 mm, thickness, from 0.05 to 1.2 mm; number of seeds per pod, from 1 to 6; and 1000 seed weight varies from 25 to 38g. Number of seeds per litre vary from 19000 to 31000 and seeds per kg vary from 26200 to 45500. The details are given in Table 35.

**Table 35. Seed characteristics of *D. sissoides***

| Locality | Tree number | Seed length (cm) | Seed width (cm) | Seed thickness (cm) | Weight of 1000 seeds (g) | Number of seeds /litre | Number of seeds per kg |
|---|---|---|---|---|---|---|---|
| Panthanthode | PDs-2+3 | 0.5-0.63 (0.56) | 0.33-0.5 (0.41) | 0.05-0.1 (0.09) | 26 | 25240-29820 (27501) | 38900-39200 (39047) |
| ,, | PDs-2 | 0.53-0.64 (0.57) | 0.3-0.52 (0.42) | 0.1-0.12 (0.10) | 25 | 37300-39480 (37853) | 38000-40000 (39586) |
| ,, | PDs-1 | 0.5-0.7 (0.55) | 0.3-0.5 (0.39) | 0.05-0.1 (0.09) | 25 | 28506-30666 (29642.7) | 40000-45500 (43368) |
| Peruvaripallam | PDs-2 | 0.4-0.6 (0.54) | 0.3-0.45 (0.37 | 0.05-0.1 (0.09) | 38 | 27560-29480 (28593) | 26280-26300 (26293) |
| Sholayur | SDs-1 | 0.5-0.74 (0.63) | 0.33-0.5 (0.42) | 0.1-0.12 (0.10) | 28 | 19580-20000 (19985) | 34000-37000 (36024) |
| Over all mean | | 0.57 *(0.03) | 0.40 *(0.01) | 0.09 *(0.00) | 28.4 *(4.93) | 28714.5 *(6365.2) | 36863 *(5778) |

Figures in parenthesis indicates mean value; * figures indicates S.E. of pooled mean

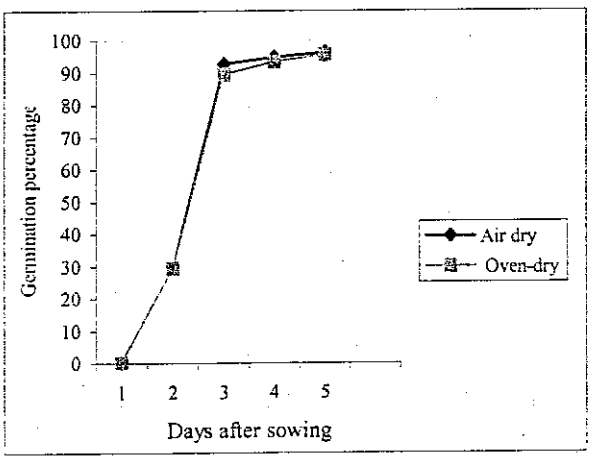
**Table 36. Mean pod and seed characteristics of seeds of *D. sissoides* from different localities**

| Seed Characteristics | Localities | | |
|---|---|---|---|
| | Chinnar | Dhoni | Wayanad |
| Length of pod (cm) | 06.16 | 06.30 | 05.80 |
| Width of pod (cm) | 01.42 | 01.68 | 01.78 |
| No. of locules per pod | 03.50 | 04.40 | 05.00 |
| No. of seeds per pod | 03.20 | 04.00 | 04.60 |
| % discoloured and deformed seeds | 22.00 | 33.00 | 26.00 |

## 2.4.3.2. Methods of drying and germination

Seeds extracted from pods soon after collection (E1) as well as those extracted after oven-drying (E2) germinated equally well with 96% germination. The details are given in Figure 10.

**Figure 10. Germination percentage of *D. sissoides* seeds dried by different methods**




Germination was better (86%) for seeds are extracted from pods as compared to broken pods (45%) and intact pods (23%) (Table. 37)

**Table 37. Germination percentage of various dissemination units of *D. sissoides***

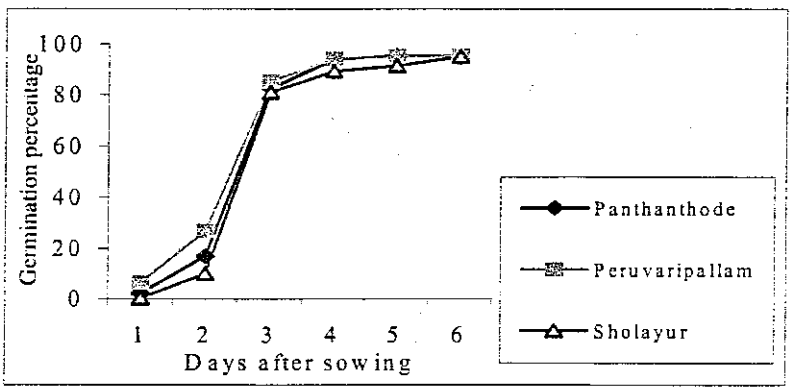
| Dissemination unit | Germination % 15 days after sowing | | | Number of days required for commencing germination | |
|---|---|---|---|---|---|
| | Dhoni | Kuppadi | Mean | Dhoni | Kuppadi |
| Full pod (germination % based on number of seeds) | 31 | 15 | 23 | 5 | 3 |
| Pod pieces (1 seed in each piece) | 67 | 23 | 45 | 3 | 3 |
| Seed | --- | 86 | 86 | --- | 1 |

--- data not available

## 2.4.3.3. Locality and germination

There is not much difference in germination percenatge of seeds collected from different localities, perhaps because the localities were nearby. Panthanthode and Peruvaripallam gave 95.5% germination six days after sowing whereas Sholayur seeds gave 95%. The details are given in Figure 11.

**Figure 11. Germination percentage of *D. sissoides* seeds collected from different localities**



## 2.4.3.4. Media and germination

Rolled towel is the best germination medium closely followed by top of paper under laboratory condition. Vermiculiite and between paper stand next. Quartz sand gave the least germination. The details are given in figures 12 (a), 12 (b), and 12 (c).

**Figure 12(a). Germination percentage of *D. sissoides* seeds of locality-1 sown in different media**

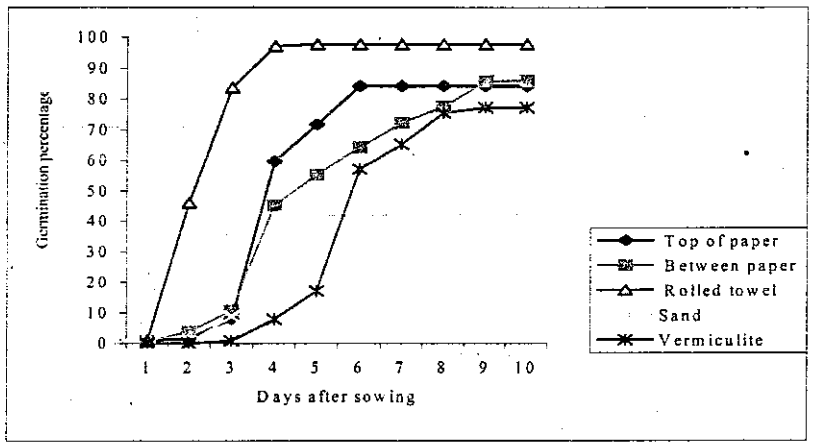



**Figure 12(b). Germination percentage of *D. sissoides* seeds of locality-2 sown in different media**

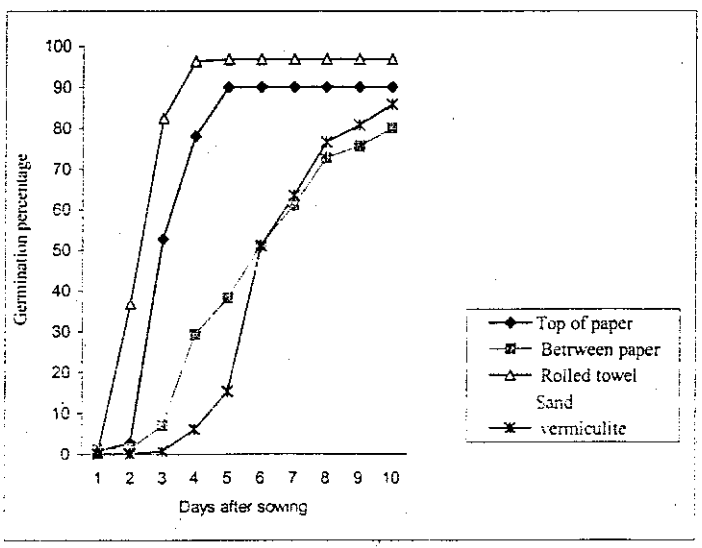
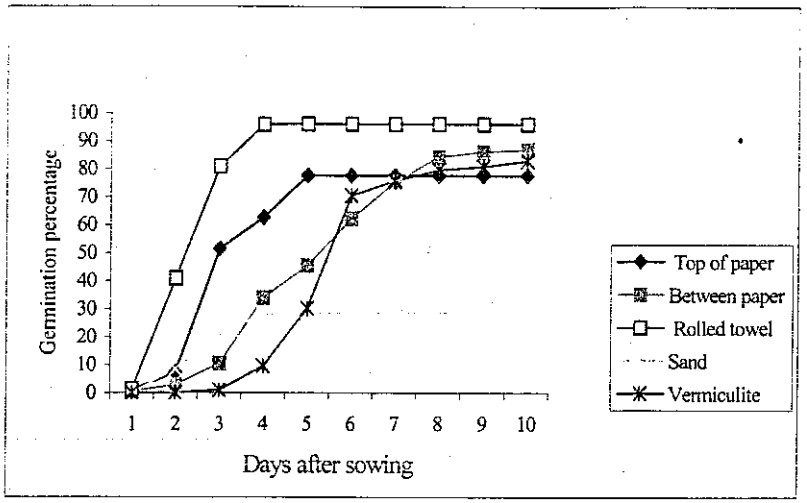


**Figure 12(c) Germination percentage of *D. sissoides* seeds of locality-3 in different media**




## 2.4.3.5. Light and germination

**Table 38. Details regarding the light conditions provided for the experiment**

| Type of covering | Quantity of Photosynthetically Active Radiation (micromole /$m^2$/s) | | |
|---|---|---|---|
| | Laboratory | Nursery shed | Open ground |
| Nil | 8 | 216 | 1619 |
| Transparent sheet (Full light) | 6 | 197 | 1535 |
| Translucent sheet (Partial light) | 4 | 138 | 1095 |
| Black polythene sheet (Zero light) | 0 | 0 | 0 |

**Test No. 1:** Germination percentage of seeds was not significantly affected by the level of light and it was good both in partial and in zero light (78%) conditions. However seeds kept under nursery condition gave more germination than seeds

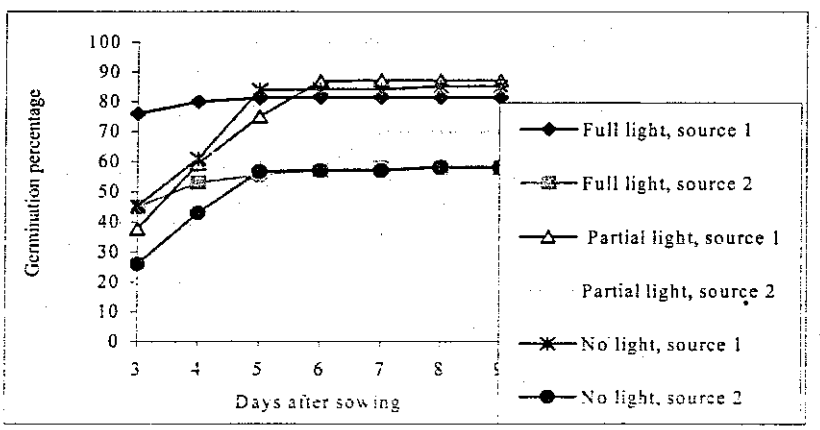
kept under laboratory condition probably because of the better temperature conditions. The details are given in Table 39.

**Table 39. Effect of light on germination of *D. sissoides* seeds**

| Shade | Laboratory | | Nursery | |
|---|---|---|---|---|
| | % germination at 10 days after sowing | | % germination at 10 days after sowing | |
| | Sholayur | Panthanthode | Sholayur | Panthanthode |
| Translucent polythene sheet (Partial light) | 87.5 | 75.5 | 91.5 | 83.8 |
| Black polythene sheet (Zero light ) | 81.3 | 78.3 | 86.5 | 82.3 |

**Test No. 2:** This test further confirms the insignificant role of light on germination of *D. sissoides* seeds. Seeds from two sources kept in full, partial and in zero light conditions in the nursery gave more or less the same trend. The details are given in Figure 13.

**Figure 13. Effect of light on germination of *D. sissoides* seeds from different sources**



## 2.4.3.6. Effect of seed size on germination

Cumulative germination percentage was high for large sized seeds. Percentage of fungal infection was less in large sized seeds than in small sized seeds. After 12 days seeds were analysed for healthy and infected ones. The details are given in Table 40.

**Table 40. Table showing percent germination, infected seeds and healthy ungerminated seeds of *D. sissoides* 12 days after sowing**

| Size category seed | Weight of 100 seeds (g) | Cumulative germination % at 12 days after sowing | % of infected seeds | % of healthy ungerminated seeds |
|---|---|---|---|---|
| Small (n=400) | 9.64 | 89.5(480) | 15.75 | 0.002 |
| Large (n=400) | 12.19 | 84 (2.9) | 10.25 | 0.002 |
| Deformed (n=29) | 0.49 | 69 | 31.03 | --- |

(Figures in parenthesis indicates S.E. of mean value)
--- indicates data not available

## 2.4.3.7. Seed pathology of *D. sissoides*

**Seed characteristics and dry seed examination**

Seeds collected from three different localities in the State viz., Chinnar, Dhoni, and Wayanad were found to be moderately affected by spermoplane microorganisms and insects. The seeds from each locality could be categorized into apparently healthy, discoloured, and deformed seeds. Percentages of seeds belonging to such categories were 78, 13 and 9 respectively in seedlot from Chinnar, 67, 21 and 12 respectively in seedlot from Dhoni and 74, 17 and 9 respectively in seedlot from Wayanad. The average weight of 100 seeds for the three categories were 3.00 g, 2.20 g and 1.9 g respectively for Chinnar, 3.01 g 2.52 g, and 2.10 g respectively for seeds from Dhoni, 3.05 g, 2.92 g, and 2.71 g

respectively for seeds from Wayanad. The weight of 100 seeds from the pooled samples from the three localities ranged from 3.00 to 3.25 g while the moisture content of seeds from different localities ranged from 12 to 15% (Table 36). The seed/fruit characteristics viz., length and width of pod, number of locules in each pod, number of seeds per pod, etc. also showed considerable variation in seedlots from these three localities (Table 36). A high percentage of discoloured and deformed seeds inside the pods indicates the possible infection by the field fungi during the developing stages of fruits and seeds.

**Seed microflora**

A rich microflora comprising 16 fungal genera, together with mycelia sterilia, bacteria and actinomycetes were detected on seeds of *D. sissoides* collected from different localities (Tables 41-43). Most microorganisms were encountered on unsterilized seeds in blotter tests. Among the seedlots, those from Wayanad and Dhoni, harboured more number of spermoplane microbes than the seeds from Chinnar. The spermoplane microbes detected include the common storage fungi, field fungi, bacteria and actinomycetes. Among the storage fungi, *Aspergillus* spp., *Penicilium* spp. and *Chaetomium* sp. were the predominant ones. The incidence of these storage fungi ranged from 38 to 69%. However, the occurrence of field fungi like *Alternaria* sp., *Curvularia* sp., *Drechslera* sp., *Bipolaris* sp., *Fusarium* spp., *Pestalotia* sp., *Phoma* sp., etc. in all the three lots ranged from 4 to 41%. Seeds from Wayanad and Dhoni were found infested by large number of field fungi and their percentages were 41 and 34 respectively. While seeds from Chinnar recorded only a few field fungi and their percent incidence was less than five. As expected, the fungal genera, their frequency of occurrence as well as intensity of infestation was more in unsteriiized seeds from all the three localities. Surface sterilization of the seeds with 0.01% mercuric chloride solution considerably reduced the occurrence of the fungal genera to 1-3 and also the percent incidence to 6-10. Even though bacteria were detected on seeds from all the three localities, their incidence was substantially reduced by surface sterilization and also by other seed pre-treatments. Cold water, hot water, and acid treatments carried out to enhance the seed germinability, were also

effective in excluding most of the spermoplane microflora. Seed health test employing agar plate method could detect a large number of field fungi like *Colletotrichum gloeosporioides*, *Curvularia* sp., *Fusarium pallidoroseum*, *Phoma* sp., *Pestalotia* sp., etc. Of these *C. gloeosporioides* was encountered in high frequency on seeds from Wayanad (25%) and Dhoni (10%). The percent incidence of *Fusarium* (mostly *F. pallidoroseum*) also ranged from 6-18 in all the seedlots. Many of these field fungi are potential pathogens of *Dalbergia sissoides* seedlings in nurseries. The results indicate that at least a few of these fungi which are possibly seed-borne may play a role in deterioration of seeds in storage as well as incidence of seedling diseases in nurseries.

**Growing-on test**

Seedling emergence started 5 to 7 days after sowing in the sterile perlite medium and continued up to 16 days. Most seedlings emerged within 10 to 12 days of sowing. Percentage germination (56) was found lower than that obtained by blotter method. Seedling infections viz., collar rot caused by *Fusarium* sp. and leaf spot caused by *Colletotrichum gloeosporioides* were recorded.

**Seed pre-treatment**

Pre-treatments of seeds viz., soaking in cold water for 24 hr, dipping in hot water and then soaking in cold water for 24 hr to break the seed dormancy and to enhance the seed germination indicate that both the seed pre-treatments were equally effective in increasing the germinability of seeds of *D. sissoides* (Table 44). Highest percent germination of 96 was observed with cold-water treatment of seeds from Dhoni.

**Table 41. Spermoplane microorganisms detected on seeds of *D. sissoides* (Chinnar 1998 seedlot) by blotter and agar methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | | | Agar plate method %incidence |
|---|---|---|---|---|---|---|---|
| | | NSS* | SS | HW | CW | A | |
| 1 | *Alternaria* sp. | - | | | | | 8.00 |
| 2 | *Aspergillus* sp. | 12.00 | | | | | |
| 3 | *Aspergillus niger* | 16.00 | 10.00 | 06.00 | 8.00 | 10.00 | 18.00 |
| 4 | *Chaetomium* sp. | 03.00 | | | | | |
| 4 | *Curvularia* sp. | | | | | | 08.00 |
| 5 | *Fusarium* sp. | 03.00 | 06.00 | | | | 14.00 |
| 6 | *Paecilomyces* sp. | 01.00 | | | | | |
| 7 | *Penicillium* sp. | 06.00 | | | | | |
| 8 | *Trichoderma* sp. | 03.00 | 02.00 | 04.00 | 8.00 | | 08.00 |
| 9 | *Verticillium* sp. | 01.00 | | | | | |
| 10 | Sterile mycelium (black) | | | 14.00 | | | 14.00 |
| 11 | Bacteria | 09.00 | 16.00 | 08.00 | 8.00 | 8.00 | 22.00 |
| 12 | Actinomycetes | | | | 6.00 | 4.00 | 04.00 |

* NSS: on-surface sterilized; SS: surface sterilized; HW: hot water treatment; CW: cold water treatment; A: sulphuric acid treatment

**Table 42. Spermoplane microorganisms detected on *D. sissoides* seeds (Dhoni 1998 seedlot) by blotter and agar plate methods and their percent incidence in different treatment**

| Sl. No. | Microorganism | Blotter metod % incidence | | | | Agar plate method % incidence |
|---|---|---|---|---|---|---|
| | | NSS | SS | HW | CW | |
| 1 | *Alternaria* sp. | 04.00 | | | | |
| 2 | *Aspergillus* spp. | 03.90 | | | | 06.00 |
| 3 | *Aspergillus niger* | 15.50 | | | | 08.00 |
| 4 | *Chaetomium* sp. | | | | 2.00 | |
| 5 | *Colletotrichum gloeosporioides* | 03.00 | | | | 10.00 |
| 6 | *Curvularia* sp. | 04.50 | | | | 04.00 |
| 7 | *Dreschelera* sp. | 03.00 | | | | |
| 8 | *Fusarium* sp. | 08.50 | | 6.00 | | 06.00 |
| 9 | *Mucor* sp. | 01.50 | | | 08.00 | |
| 10 | *Penicillium* sp. | 09.00 | | | | 02.00 |
| 11 | *Pestalotia* sp. | 02.50 | | | | 04.00 |
| 12 | *Phoma* sp. | 07.00 | | | | 04.00 |
| 13 | *Trichoderma* sp. | 07.50 | 6.00 | 6.00 | | |
| 14 | *Trichothecium* sp. | 00.75 | | | | |
| 15 | *Verticillium* sp. | 01.50 | | | | |
| 16 | Sterile mycelium (White) | 08.00 | | 2.00 | 02.00 | 06.0 |
| 17 | Sterile mycelium (black) | 06.00 | | | | 06.0 |
| 18 | Bacteria | 25.50 | 9.00 | 8.0 | 12.0 | 06.0 |
| 19 | Actinomycetes | 05.00 | 6.00 | 4.0 | 06.0 | |

*NSS: non-surface sterilized; SS: surface sterilized; HW: hot water treatment; CW: cold water treatment

**Table 43. Spermoplane microorganisms detected on *D. sissoides* seeds (Wayanad 1998 seedlot) blotter and agar plate methods and their percent incidence in different treatments**

| Sl. No. | Micororganisms | Blotter method % incidence | | | | Agar plate method % incidence |
|---|---|---|---|---|---|---|
| | | NSS | SS | HW | CW | |
| 1 | *Alternaria* sp. | 07.00 | | | | |
| 2 | *Aspergillus* spp. | | | 2.00 | 6.00 | 04.00 |
| 3 | *Aspergillus niger* | 18.00 | 06.00 | 4.00 | 6.00 | 03.00 |
| 4 | *Bipolaris* sp. | 02.00 | | | | |
| 5 | *Cephalosporium* sp. | 03.00 | | | | |
| 6 | *Colletotrichum* sp. | 05.00 | | | | 25.00 |
| 7 | *Dreschelera* sp. | 06.00 | | 2.00 | | |
| 8 | *Chaetomium* sp. | 06.00 | 06.00 | | | |
| 9 | *Curvularia* sp. | 04.00 | | | 4.00 | |
| 10 | *Fusarium* sp. | 05.00 | | | | 18.00 |
| 11 | *Mucor* sp. | 01.00 | | | | |
| 12 | *Paecilomyces* sp. | 04.00 | | | | |
| 13 | *Penicillium* sp. | 08.00 | | | 4.00 | |
| 14 | *Pestalotia* sp. | 02.00 | | | | |
| 15 | *Phoma* sp. | 07.00 | | 8.00 | 6.00 | 17.00 |
| 16 | *Trichoderma* sp. | 12.00 | 08.00 | 6.00 | 4.00 | 12.00 |
| 17 | *Verticillium* sp. | 03.00 | | | | |
| 18 | Sterile mycelium (black) | 08.00 | - | | | 2.00 |
| 19 | Sterile mycelium (White) | 09.00 | | | | 6.00 |
| 20 | Bacteria | 28.00 | 12.00 | 6.00 | | 14.00 |
| 21 | Actinomycetes | 10.00 | 04.00 | 4.00 | 4.00 | 2.00 |

**Table 44. Effect of various seed pre-treatments on percent germination of *D. sissoides* seeds collected from different localities in the State.**

| Locality | Zone | Sub-zone | Percent germination | | | |
|---|---|---|---|---|---|---|
| | | | NSS | SS | HW | CW |
| Dhoni | KL3 | b | 38 | 47 | 82 | 96 |
| Chinnar | KL2 | b | 4 | 14 | 20 | 38 |
| Wayanad | KL3 | c | 54 | 64 | 94 | 80 |

*NSS: non-surface sterilized;SS: surface sterilized; HW: hot water treatment; CW: cold water treatment

**Plate 9. Mature pods of *D. sissoides***

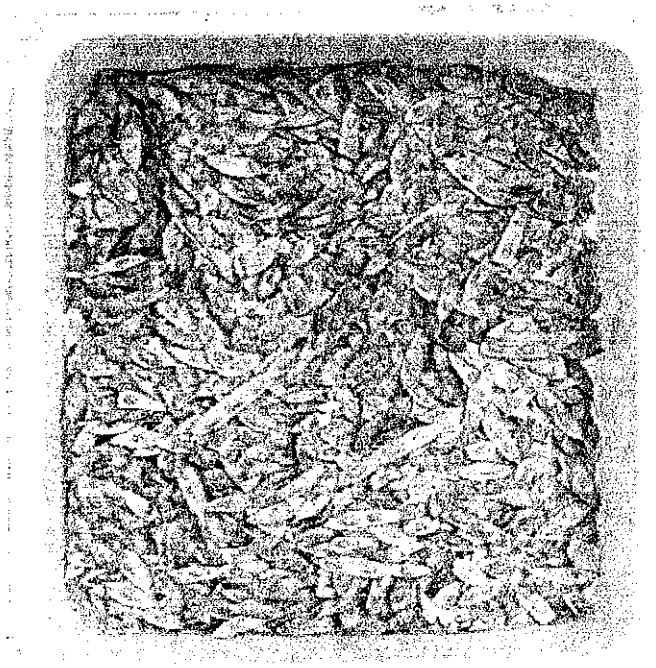
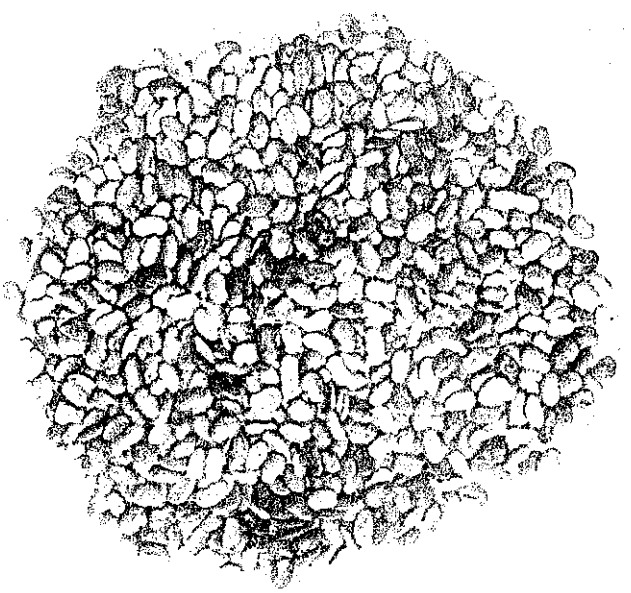


**Plate 10. Seeds of *D. sissoides***



## 2.4.4. *Neolamarckia cadamba*

### Seed collection areas

In Kerala, *N. cadamba* grows in moist deciduous (nearly evergreen) forests of Dhoni, Nilambur, Wayanad and Konni near and along streams. At Kannimangalam in Malayattur Division this species is grown as a plantation crop by the Kerala Forest Department. Seed trees were identified at all the three Zones. In Zone1, the seed trees were identified at Aruvapalam at Konni Sub-zone. In Zone 2, the seed trees were identified at Kannimangalam in Malayattur Sub-zone and at Irinjalakkuda in Thrissur Sub-zone. In Zone 3, the seed trees were identified at Mukkali and Dhoni in Palakkad Sub-zone and at Nellikkuthu in Nilambur Sub-zone. Tallest tree observed at Mukkali had a height of 45m and the one with largest girth measured 328cm at Vayakkara in Konni Sub-zone. Details of trees marked are given in Table 45.

**Table 45. Seed collection areas of *N. cadamba* in Kerala**

| Seed zone | Sub- zone | Locality | Tree No. | GBH (cm) | Height (m) |
|---|---|---|---|---|---|
| KL-1 | Konni | Naduvathumuzhi | NAc-1 | 223 | 34 |
| | | | NAc-2 | 221 | 31 |
| | | Vayakkara | VAc-3 | 328 | 42 |
| | | | VAc-4 | 131 | 21 |
| KL-2 | Munnar | Adimali | VAc-1 | ---- | ---- |
| | | Kannimangalam | KAc-1 | ---- | ---- |
| | Malayattur | | KAc-2 | 173 | 34 |
| | | | KAc-3 | 139 | 30 |
| | | | KAc-4 | 140 | 27 |
| | | | KAc-5 | 135 | 21 |
| KL-3 | Palakkad | Dhoni | DAc-1 | 218 | 45 |
| | | | DAc-2 | 138 | 27 |
| | | Mukkali | MAc-1 | 278 | 45 |
| | Nilambur | Nellikkuthu | NAc-1 | 257 | 21 |
| | | | NAc-2 | 315 | 43 |
| | | | NAc-3 | 230 | 34 |
| | | | NAc-4 | 180 | 27 |
| | | | NAc-5 | 200 | 41 |
| | | | NAc-6 | 250 | 30 |
| | Wayanad | Ondayangadi | OAc-1 | 190 | 20 |
| | | | OAc-2 1A) | 167 | 21 |
| | | | OAc-3 (1B) | 213 | 29 |
| | | | OAc-4 | 187 | 33 |
| | | | OAc-5 | 175 | 21 |
| | | | OAc-6 | 151 | 25 |
| | | | OAc-7 | 133 | 29 |
| | | | OAc-8 | 170 | 29 |
| | | | OAc-9 | 104 | 18 |
| | | | OAc-10 | 124 | 22 |
| | | | OAc-11 | 148 | 19 |
| | | | OAc-12 | 104 | 17 |
| | | | OAc-13 | 147 | 24 |
| | | | OAc-14 | 081 | 14 |
| | | | OAc-15 | 165 | 22 |
| | | | OAc-16 | 110 | 17 |
| | | | OAc-17 | 140 | 22 |

---- not available

*The distance between trees is more than 100 m except for.OAc-2 and OAc-3.

NAc-1 Naduvathumuzhi *Anthoephalus chinensis* number 1; VAc-1 Vayakkara *Anthoephalus chinensis* number 1
AAc-1 Adimali *Anthoephalus chinensis* number 1; KAc-1 Kannimangalam *Anthoephalus chinensis* number 1
DAc-1 Dhoni *Anthoephalus chinensis* number 1; MAc-1 Mukkali *Anthoephalus chinensis* number 1
NAc-1 Nellikkuthu *Anthoephalus chinensis* number 1; OAc-1 Ondayangadi *Anthoephalus chinensis* number 1

## Phenology of flowering and fruiting

In Kerala, flowering occurs during May-July. Fruit collection period is generally from August-November. In Nilambur, fruits are available from early August to October. At Kannimangalam, Wayanad and Irinjalakkuda, fruits are available from September to November. Peak period of collection is September. Details regarding phenology of flowering and fruit collection, fruit crop assessment is given in Table 46.

**Table 46. Phenology of flowering and fruiting of *N. cadamba* in Kerala**

| Zone | Sub-zone | Locality | Year | Flowering period | Fruit collection period | Seed crop |
|---|---|---|---|---|---|---|
| KL-1 | Konni | Aruvapalam | 1998 | June-July | September-October | ---- |
| KL-2 | Malayattur | Kannimangalam | 1998 | June-July | Mid August-October | Poor |
| | | | 1999 | June-July | September-November | Average |
| | Thrissur | Irinjalakkuda | 1999 | June-July | September-November | Poor |
| KL-3 | Palakkad | Mukkali | 1998 | June-July | September-October | Poor |
| | | Dhoni | 1997 | ------ | November | Good |
| | | | 1998 | June- July | August-mid November | Good |
| | | | 1999 | " | Sept-mid November | Good |
| | Nilambur | Nellikkuthu | 1997 | ------ | November | Good |
| | | | 1998 | June- July | Mid August-October | Good |
| | | | 1999 | May-June | Mid August-Early October | Good |
| | Wayanad | Ondayangadi | 1998 | June-July | Mid August-October | Poor |
| | | | 1999 | | September-November | Poor |

--- not available

### 2.4.4.1. Fruit collection and seed extraction

As most trees are tall and the fruits fall soon after ripening, collection from forest floor is the most convenient method. From small trees, fruits were collected using a stick with attached sickle. Fruits were sun-dried until they became brittle and seeds were extracted by rubbing the brittle fruits on a metal grater (Plate 11). Seeds were separated from the chaff by sieving through a 0.5 mm sieve.

In wet method of extraction (Plate 12), fruits were allowed to rot for three to four days and rotten fruits were crushed in water and the seeds were separated from the slurry by repeated pouring out process. Slurry was sun-dried and pure seeds were separated using a 0.5 mm sieve. Both the methods of extraction (sun-dry and wet) are equally good, but wet method of extraction is time taking and tedious.

**Fruit characteristics**

Fruits measure 3.7 cm to 5.1 cm in length and 3.6 cm to 5.3 cm in diameter. Fresh weight of a fruit varies between 12 g and 72 g, number of capsules per fruit varies between 470 and 905. Capsule length varies between 0.75 cm and 1.32 cm, width varies from 0.25 cm to 0.35 cm. Number of seeds per capsule vary between 25 to 100. The details are given in Table 47.

**Table 47. Fruit characteristics of *N. cadamba***

| Sl No. | Locality | Date of collection | Tree no. | Mean | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Fruit diameter (cm) | Fruit length (cm) | Fresh weight of a single fruit (g) | Number of capsule Per fruit | Number of seeds per fruit | Capsule length (cm) | Capsule width (cm) | Peduncle diameter (cm) |
| 1 | Nellikkuthu | 14/11/97 | Different trees | 5.28 (0.20) | 5.14 (0.01) | 72.14 (3.53) | 754.5 (269.4) | 39.75 (28.01) | --- | --- | --- |
| 2 | „ | 17/10/98 | NAc-4 | 4.41 (0.52) | 4.9 (0.2) | 33.53 (10.32) | 571.5 (108.5) | --- | --- | --- | --- |
| 3 | „ | 17/10/98 | NAc-(1) mixed | 4.36 (0.17) | 4.44 (0.22) | 12.56 (0.45) | 497.5 (166.1) | --- | --- | --- | --- |
| 4 | Mukkali | 24/09/98 | MAc-1 | 4.16 (0.23) | 4.09 (0.47) | 36.43 (6.02) | 598 (188.2) | --- | --- | --- | --- |
| 5 | Dhoni | 18/09/98 | DAc-1 | 4.31 (0.63) | 4.3 (0.45) | --- | --- | --- | --- | --- | --- |
| 6 | „ | „ | DAc-2 | 4.73 (0.55) | 3.96 (0.63) | --- | --- | --- | --- | --- | --- |
| 7 | „ | 22/10/98 | DAc-1 | 4.06 (0.32) | 4.07 (0.24) | 20.78 (0.17) | --- | --- | 0.75 (0.13) | 0.25 (0.030) | 2.05 (0.07) |
| 8 | „ | „ | Mixed-1 | 4.78 (0.44) | 4.26 (0.46) | 27.76 (6.42) | 473.5 (115.2) | --- | --- | --- | --- |
| 9 | „ | 09/11/98 | Mixed-2 | 4.84 (0.43) | 4.82 (0.43) | 42.68 (23.17) | 537.4 (198.1) | 96.64 (8.32) | --- | --- | --- |
| 10 | „ | „ | DAc-3 | 4.62 - (0.41) | 4.90 (0.26) | 49.10 (9.64) | 779 (103.8) | 91.4 (7.14) | 1.28 (1.08) | 0.32 (0.03) | 2.54 (0.36) |
| 11 | „ | 22/10/98 | „ | --- | --- | 46.73 (22.57) | 691.5 (372.6) | --- | --- | --- | --- |
| 12 | „ | „ | Mixed-2 | 4.47 (0.87) | 4.71 (0.51) | 34.18 (15.37) | 904.5 (426.3) | --- | --- | --- | --- |
| 13 | Kannimangalam | 19/09/98 | KAc-6 | 4.36 (0.54) | 4.47 (0.67) | --- | --- | --- | --- | --- | --- |
| 14 | „ | „ | KAc-1 | 3.58 (0.50) | 3.66 (0.31) | --- | --- | --- | --- | --- | --- |
| 15 | „ | 06/11/98 | KAc-5 | 4.63 (0.36) | 3.92 (0.17) | --- | 683.5 (40.30) | 28.00 (10.30) | --- | --- | --- |

(Figures in parentheses S.E. of Mean value)
---data not available

Quantity of seed obtained from 1kg fresh fruit after wet method of extraction is 23g to 30g, 1kg sun-dried fruits yield 81g to 270g seeds. 1kg oven-dried fruits yielded 190g to 250g seeds. The details are given in Table 48.

**Table 48. Details of seed extraction method and weight of seed obtained**

| Sl No. | Locality | Date of collection | Tree No. | Fresh weight of fruit (g) | Dry weight of fruit (g) | Method of extraction | Weight of seed obtained (g) | Weight of seed obtained from one kg fruit |
|---|---|---|---|---|---|---|---|---|
| 1 | Kannimangalam | 19/09/98 | KAC-6 | - | 082.10 | Sun-dry | 10.24 | 124.75 |
| 2 | Dhoni | 18/09/98 | DAC-1 | 112.30 | 030.10 | " | 08.00 | 265.98 |
| 3 | " | " | DAC-2 | - | 042.43 | " | 07.76 | 182.88 |
| 4 | " | 07/10/98 | DAC-3 | - | 384.40 | " | 45.79 | 119.12 |
| 5 | " | 22/10/98 | Mixed-1 | - | 204.20 | " | 35.36 | 173.16 |
| 6 | " | 09/11/98 | Mixed-2 | 112.00 | 031.69 | " | 07.29 | 230.00 |
| 7 | " | " | Mixed-2 | 203.00 | 073.86 | " | 16.08 | 217.70 |
| 8 | " | " | DAC-3 | 274.14 | - | Wet | 06.50 | 023.71 |
| 9 | " | " | Mixed-2 | 170.75 | - | " | 05.23 | 030.62 |
| 10 | " | " | DAC-3 | 533.00 | 163.74 | Oven-dry | 40.15 | 245.20 |
| 11 | " | " | Mixed-2 | 161.77 | 059.92 | " | 11.68 | 194.92 |
| 12 | Mukkali | 24/09/98 | MAC-1 | - | 052.05 | Sun-dry | 05.61 | 107.78 |
| 13 | Nilambur | 07/10/98 | NAC-4 | - | 384.40 | " | 45.70 | 118.88 |
| 14 | " | 06/10/98 | NAC-3 | - | 058.91 | " | 04.78 | 081.14 |
| 15 | Ondayangadi | 09/10/98 | OAC-Mixed | - | 119.97 | " | 10.25 | 085.43 |

-- not available

**Seed characteristics:** Seed length varies between 0.59 mm to 0.68 mm and width between 0.41 mm to 0.48 mm. The details are given in Table 49.

**Table 49. Seed characteristics of *N. cadamba***

| Sl. No. | Locality | Date of collection | Tree No. | Mean length (mm) | Mean width (mm) |
|---|---|---|---|---|---|
| 1 | Kannimangalam | 06/11/98 | KAc-5 | 0.6023 (0.0783) | 0.4133 (0.0660) |
| 2 | Nellikkuthu | 17/10/98 | NAc1-Mixed | 0.6726 (0.0581) | 0.4750 (0.0369) |
| 3 | Ondayangadi | 09/10/98 | DAc-Mixed | 0.6764 (0.0412) | 0.4693 (0.0430) |
| 4 | Dhoni | 09/11/98 | DAc-3 | 0.5909 (0.352) | 0.4351 (0.414) |

(Figures in parentheses S. E. of Mean value)

Weight of 1000 seeds varies from 0.035 g to 0.043 g; 2,30,00,000 to 3,12,50,000 seeds weigh a kilogram. Details are given in Table 50.

**Table 50. Table showing 1000 seed weight and seeds per kg**

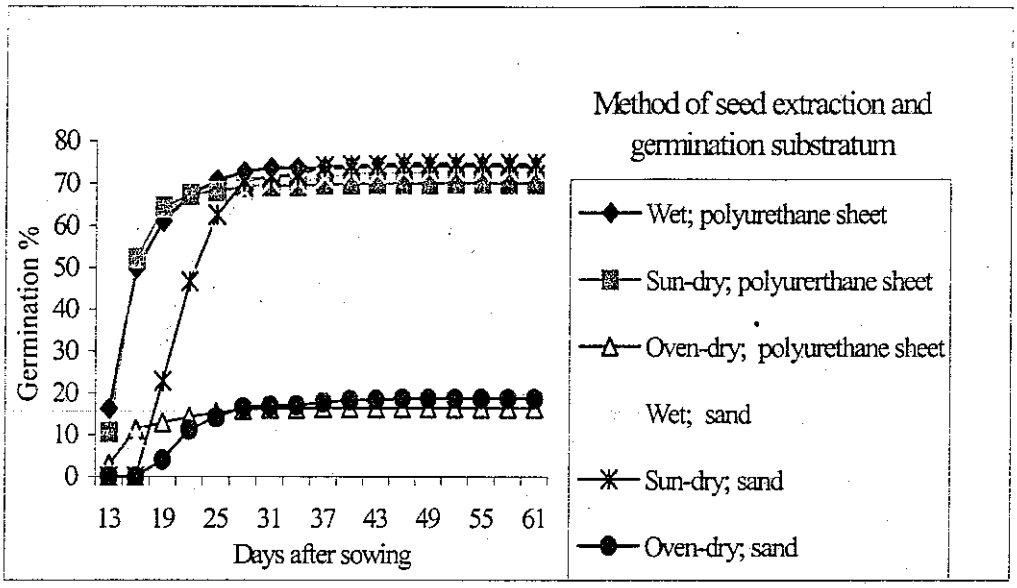
| Sl. No. | Locality | Tree No. | Date of collection | Method of extraction | 1000 seed weight (g) | Seeds per kg |
|---|---|---|---|---|---|---|
| 1 | Kannimangalam | KAc-5 | 19/09/98 | Sun-dry | 0.0378 | 27027027 |
| 2 | " | " | 06/11/98 | Wet | 0.0378 | 27027027 |
| 3 | " | Mixed | 07/11/98 to 10/11/98 | " | 0.0320 (0.0001) | 31250000 |
| 4 | Mukkali | MAc-1 | 24/09/98 | Sun-dry | 0.0425 | 23529411 |
| 5 | Nilambur | NAc(R)-3 | 07/10/98 | " | 0.0418 (0.0018) | 23923444 |
| 6 | " | NAc(L)-Mixed | " | Wet | 0.0421 (0.0003) | 23752969 |
| 7 | " | NAc-4 | 17/10/98 | Sun-dry | 0.0431 (0.0010) | 23201856 |
| 8 | Dhoni | DAc-1 | 18/09/98 | " | 0.0415 (0.0012) | 24096385 |
| 9 | " | " | 22/10/98 | Wet | 0.0367 (0.0014) | 27247956 |
| 10 | " | Mixed-2 | " | Sun-dry | 0.0355 | 28169014 |
| 11 | " | Mixed-1 | " | " | 0.0355 | 28571428 |
| 12 | " | Mixed | 09/11/98 | Wet | 0.0388 | 25773195 |
| 13 | " | DAc-3 | " | " | 0.0348 (0.0028) | 28735632 |
| Over all mean | | | | | 0.0388 (0.00036) | 26331180 (2509548) |

Figures in parenthesis indicate the S.E. of Mean value

## 2.4.4.2. Methods of extraction and germination

Sun-dry and wet method of extraction gave more or less equally good germination (70-75%), whereas oven-drying at 50°C reduced germination probably due to lethal effect of temperature. The details are given in Figure 14.

**Figure 14. Germination of *N. cadamba* seeds extracted by different methods**




## 2.4.4.3. Method of extraction on seed purity and moisture content

**Seed purity**

Seeds extracted by wet method were 99% pure sun-drying 87%, and oven-drying 85%. On purity basis wet method is better than the dry methods. The seeds extracted by different methods showed nearly same moisture content. The details are given in Table 51.

**Table 51. Purity percentage of seeds extracted by different methods**

| Seed lot number | Percentage of Purity | | | Moisture content % | | |
|---|---|---|---|---|---|---|
| | Sun dry | Wet | Oven dry | Sun dry | Wet | Oven dry |
| 1 | 86.2 | 99.0 | 84.1 | 11.9 | 11.9 | 11.8 |
| 2 | 86.6 | 99.0 | 85.2 | 11.3 | 11.0 | 11.7 |
| Mean | 86.7 | 99.0 | 84.6 | 11.2 | 11.4 | 11.8 |

## 2.4.4.4. Effect of season of collection and media on germination

Seeds collected during the late seed season (November) gave maximum germination (figure 15). However whether it is due to freshness of the seeds or due to the season needs confirmation. Studies on germination of seeds from three different

sources using polyurethane and sand as media showed that best germination occurs on polyurethane foam (33.5%, 56.25% and 65.8% for the sources S1, S2 and S3 respectively) followed by quartz sand (56.25%, 22.88%, 59% for the sources S1, S2 and S3 respectively). Germination towel in laboratory condition is a poor medium (0 %) The details of germination are given in Figure 15.. Contrary to this finding, Beniwal and Dhawan (1991) reported a germination of 75% in germination paper in laboratory condition than the seeds sown in nursery soil, sand, sand/soil (1:1), soil/sand/ FYM (1:1:1).

**Figure 15. Effect of media and season of collection on germination of *N.cadamba* seeds**

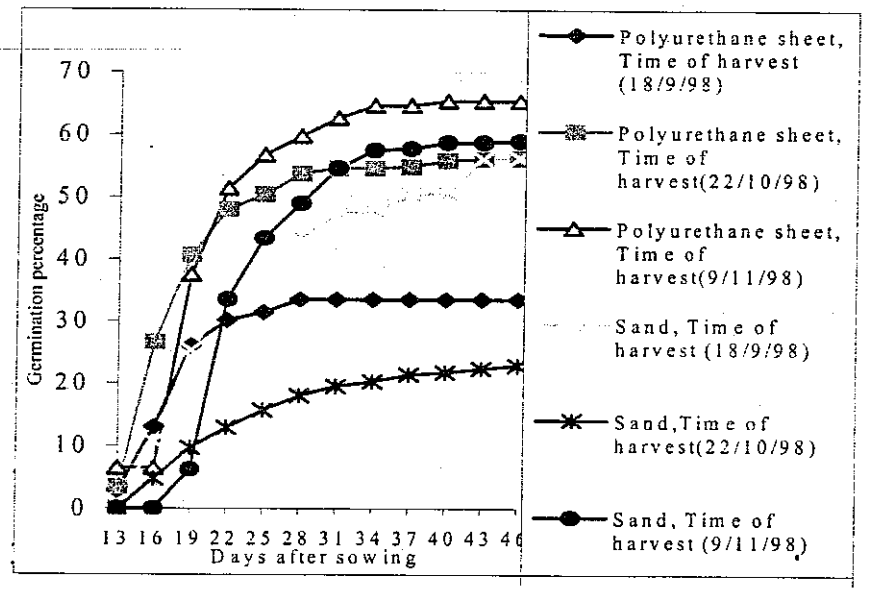
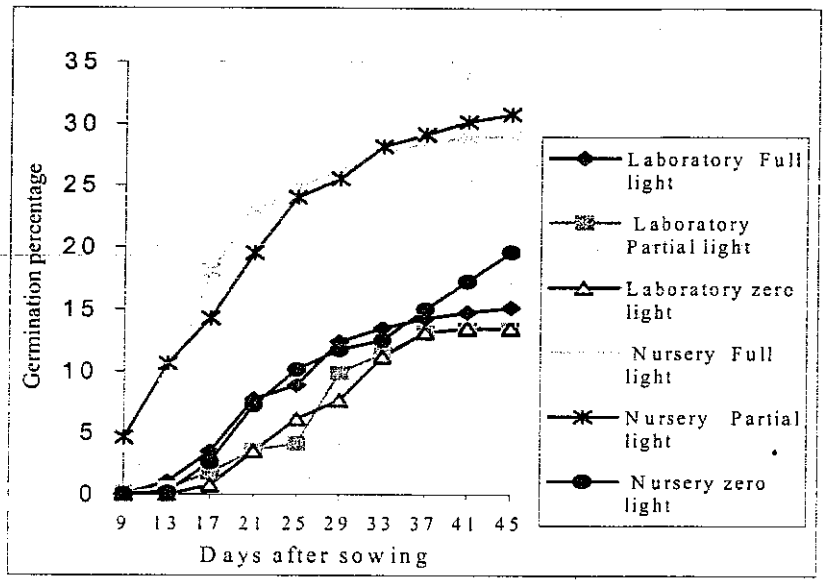



**Table 52. Details regarding the light conditions provided for the experiment**

| Type of covering | Quantity of Photosynthetically Active Radiation (micromole /$m^2/s^2$) | | |
|---|---|---|---|
| | Laboratory | Nursery shed | Open ground |
| Nil | 8 | 216 | 1619 |
| Transparent sheet | 6 | 197 | 1535 |
| Translucent sheet | 4 | 138 | 1095 |
| Black polythene sheet | 0 | 0 | 0 |

Of the three light conditions provided (zero, partial, and full) in nursery and in laboratory, germination was better in full and partial light conditions as compared to zero light condition. The details are given in Figure 16.

**Figure 16. Effect of light on germination of *N. cadamba* seeds**




## 2.4.4.6. Fruit colour and germination

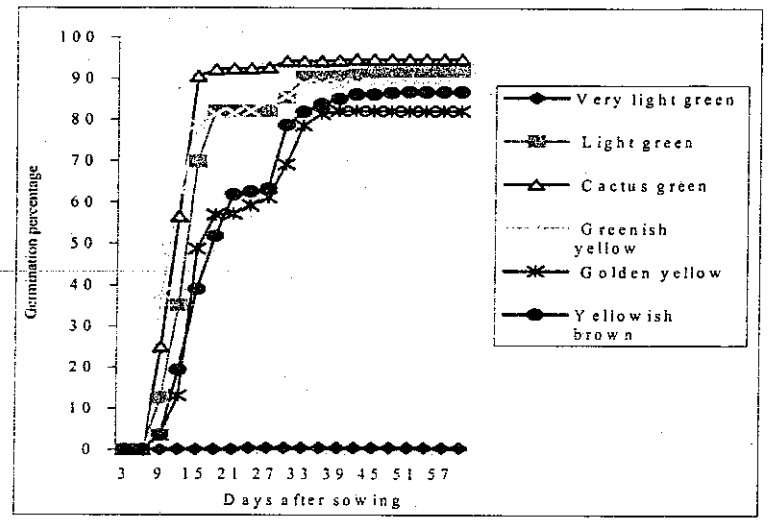
Fruit colour and seed colour at different stages of their maturity is shown in plate 13 and described in Table 53.

**Table 53. Fruit and seed colour of *N. cadamba***

| Colour of the fruit | Colour of the seed |
|---|---|
| Very light green | Light cream |
| Light green | Light brown |
| Cactus green | Brown |
| Greenish yellow | Brown |
| Golden yellow | Deep brown |
| Yellowish brown | Deep brown |

Seeds with light brown to deep brown colour are physiologically mature enough to give germination above 80%. Fruits enclosing such seeds develop colour break from very light green to light green and finally to yellowish brown.

**Figure 17. Effect of fruit colour on germination of *N. cadamba* seeds**




## 2.4.4.7. Seed pathology of *N. cadamba*

**Dry seed examination**

Seeds collected from four different localities were subjected to the studies. The minute seeds exhibited marked discolouration, especially in seedlots from Walayar and Kannimangalam. Surface molds were also observed on discoloured seeds. No attempt was made to categorize the seeds into apparently healthy, discoloured and deformed seeds from each seedlots due to practical problems.

**Seed microflora**

Seeds from all the four localities in the State showed comparatively poor microflora represented by 2 to 3 fungal genera belonging to the group of storage fungi and about 5 field fungi. The percent incidence of all the spermoplane microbes was also less and ranged from 1 to 8. As usual, more number of microbes harboured unsterilized seeds than surface sterilized seeds. Interestingly, surface sterilization of seeds from Kannimangalam completely excluded the spermoplane fungal flora. *Aspergillus* spp. *Chaetomium* sp., *Mucor* sp. and *Trichoderma* sp. were the storage

fungi encountered while, *Colletotrichum gloeosporioides, Drechslera* sp., *Fusarium* sp. *Pestalotia* sp. and *Phoma* sp. were the field fungi recorded. Association of bacteria and their percent incidence were also less, which ranged from 3 to 4 in all the treatments (Tables 54-57). Seed pre-treatment with sulphuric acid to enhance the seed germination also helped in removing the spermoplane fungal flora. The treatment was highly effective and no fungal flora except sterile mycelium was observed on treated seeds. Agar plate method also yielded only a few fungal species from the seedlots from different localities. *Fusarium oxysporum, Phoma* sp., *Pestalotia* sp., etc were the important field fungi found associated with the seeds.

**Seed pre-treatment**

In blotter test, both unsterilized and surface sterilized seeds from the four different localities gave a very low percent germination, which ranged from 0 to 13. Hence, sulphuric acid treatment was carried out and comparatively high percent germination was obtained for all the seedlots, which ranged from 22 to 43. Highest percent germination of 43 was obtained for seedlot from Nilambur (Table 58).

**Table 54. Spermoplane microorganisms detected on seeds of *N. cadamba* (1998 Dhoni seedlot) and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate % incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Alternaria* sp. | 1 | - | | 1 |
| 2 | *Aspergillus* sp. | 15 | 1 | 2 | |
| 3 | *Aspergillus niger* | 4 | | | |
| 4 | *Curvularia* sp. | 6 | | 1 | 2 |
| 5 | *Drechslera* sp. | 2 | | | 1 |
| 6 | *Fusarium oxysporum* | 8 | | | |
| 7 | *Pestalotia* sp. | | | | 2 |
| 8 | *Phoma* sp. | 4 | 3 | | 2 |
| 9 | *Trichoderma* sp. | 3 | 4 | | |
| 10 | Bacteria | 6 | 4 | 4 | 3 |

*NSS: non-surface sterilized; SS: surface sterilized; A: sulphuric acid treatment

**Table 55. Spermoplane microorganisms detected on seeds of *N. cadamba* (1998 Nilambur seedlot) by blotter and agar plate methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method %incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Alternaria* sp. | 1 | | | 1 |
| 2 | *Aspergillus* spp | 3 | 4 | | 2 |
| 3 | *Aspergillus niger* | 2 | | | 2 |
| 4 | *Chaetomium* sp. | 3 | | | |
| 5 | *Curvularia* sp. | 2 | | | 1 |
| 6 | *Colletotrichum gloeosporioides* | 1 | | | |
| 7 | *Drechslera* sp. | 2 | 1 | | |
| 8 | *Fusarium oxysporum* | 2 | | | 2 |
| 9 | *Pestalotia* sp. | 3 | | | 1 |
| 10 | *Phoma* sp. | 3 | | | 3 |
| 11 | *Trichoderma* sp. | 4 | 2 | | 1 |
| 12 | Sterile mycelium (White) | | | 2 | |
| 13 | Bacteria | 3 | 4 | 3 | |
| 14 | Actinomycetes | | | 1 | |

*NSS: non-surface sterilized;SS: surface sterilized; A: sulphuric acid treatment

**Table 56. Spermoplane microorganisms detected on seeds of *N. cadamba* (1998 Wayanad seedlot) and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method %incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Alternaria* sp. | 1 | | | 2 |
| 2 | *Aspergillus niger* | | 2 | 2 | 2 |
| 3 | *Colletotrichum gloeosporioides* | 1 | | | |
| 4 | *Curvularia* sp. | 2 | | | 1 |
| 5 | *Fusarium oxysporum.* | 4 | | | 2 |
| 6 | *Pestalotia* sp. | 1 | | | 1 |
| 7 | *Phoma* sp. | 3 | | | 1 |
| 8 | *Trichoderma* sp. | 3 | 2 | | 1 |
| 9 | Sterile mycelium (White) | 3 | | | |
| 10 | Bacteria | | 3 | 2 | |
| 11 | Actinomycetes | | 2 | 1 | |

*NSS: non-surface sterilized: SS: surface sterilized; A: sulphuric acid treatment

**Table 57. Spermoplane microorganisms detected on seeds of *N. cadamba* (Kannimangalam 1998 seedlot) and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method % incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Alternaria* sp. | 1 | | | 2 |
| 2 | *Aspergillus* spp. | 4 | | | |
| 3 | *Aspergillus niger* | | | 1 | 1 |
| 4 | *Colletotrichum glooeosporioides* | 1 | | | |
| 5 | *Curvularia* sp. | 5 | | | 3 |
| 6 | *Drechslera* sp. | 1 | | | |
| 7 | *Fusarium oxysporum.* | | | | 2 |
| 8 | *Pestalotia* sp. | 2 | | | |
| 9 | *Phoma* sp. | 1 | | | |
| 10 | *Mucor* sp. | | | | 2 |
| 11 | *Trichoderma* sp. | 2 | | 1 | 1 |
| 12 | Sterile mycelium (White) | | | 2 | 2 |
| 13 | Bacteria | 4 | 3 | 3 | 3 |
| 14 | Actinomycetes | 1 | 1 | 1 | 1 |

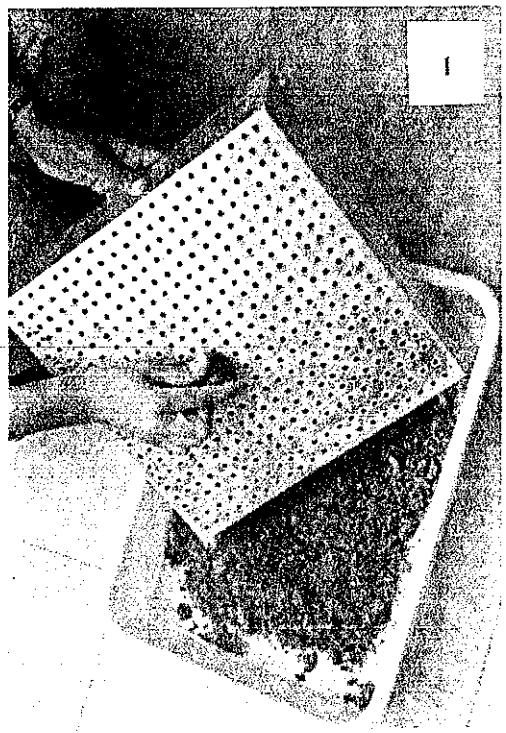
*NSS: non-surface sterilized; SS: surface sterilized; A: sulphuric acid treatment

**Table 58. Effect of various treatments on percent germination of *N. cadamba* seeds collected from different agro climatic zones of the State.**

| Locality | Zone | Sub-zone | Per cent germination | | |
|---|---|---|---|---|---|
| | | | NSS | S | A |
| Kanimangalam | KL-3 | e | 5 | 3 | 23 |
| Nilambur | KL-3 | c | 2 | 4 | 43 |
| Dhoni | KL-3 | b | 10 | 13 | 30 |
| Wayanad | KL-3 | e | 0 | 3 | 22 |

*NSS: non-surface sterilized; SS: surface sterilized; A: sulphuric acid treatment

Plate 11. 1. Extraction of *N. cadamba* seeds using metal grater; 2. sieving the seeds through 0.5mm sieve; 3. seeds extracted by sun- dry method





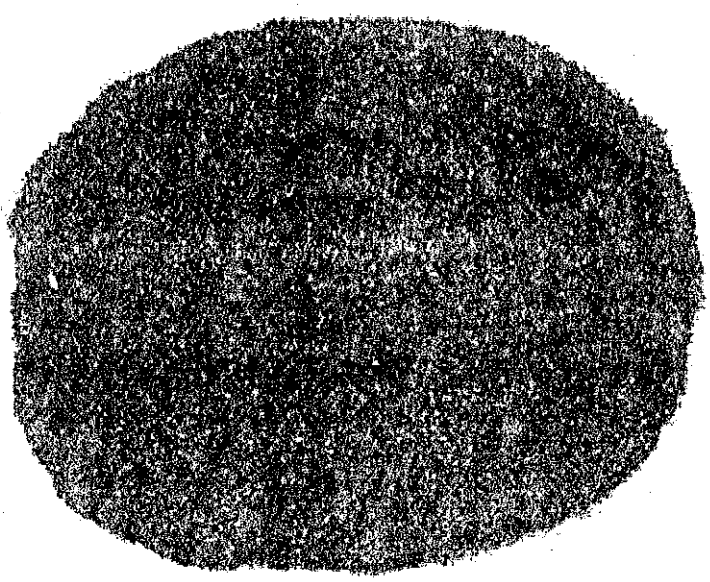
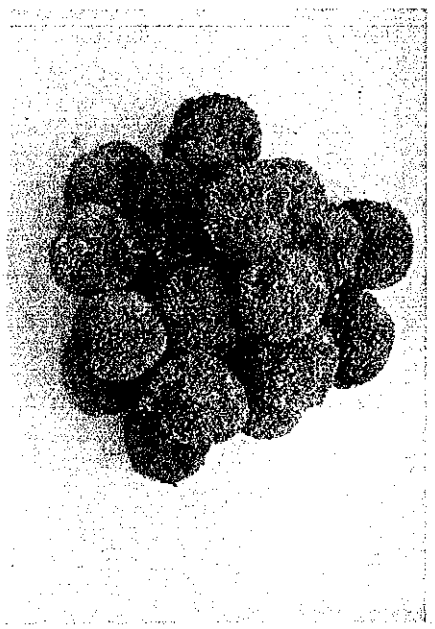
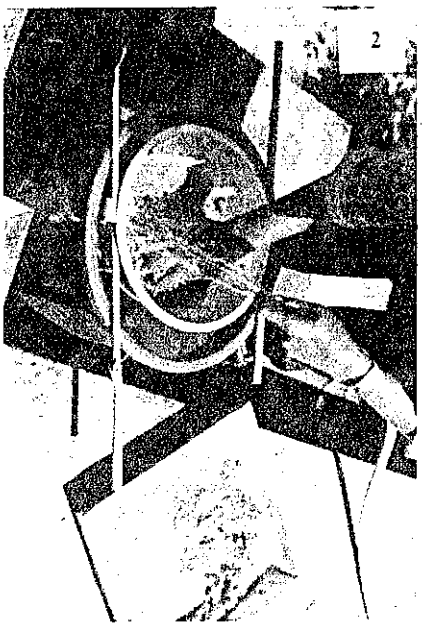


**Plate 12. Wet method of seed extraction of *N. cadamba* fruits; 1. Rotten fruits, 2-4 Slurry preparations**







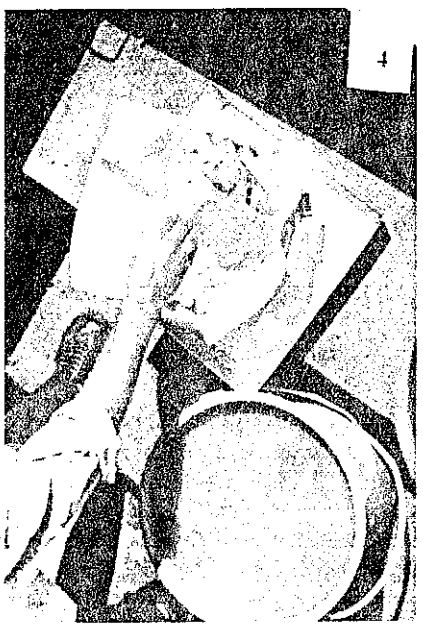
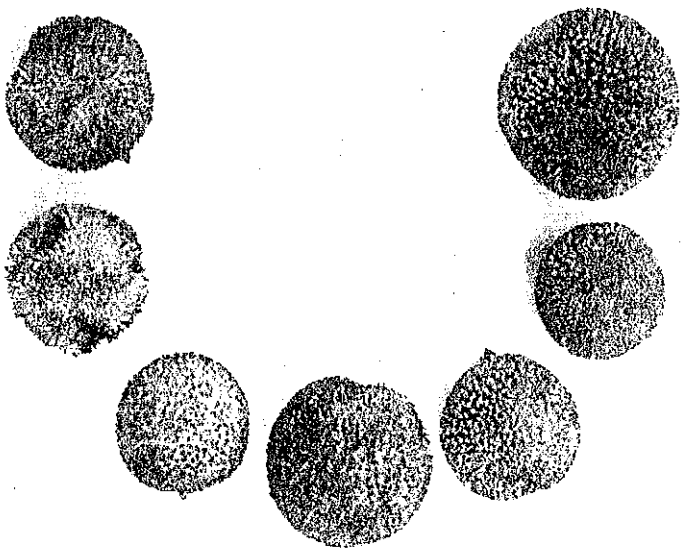
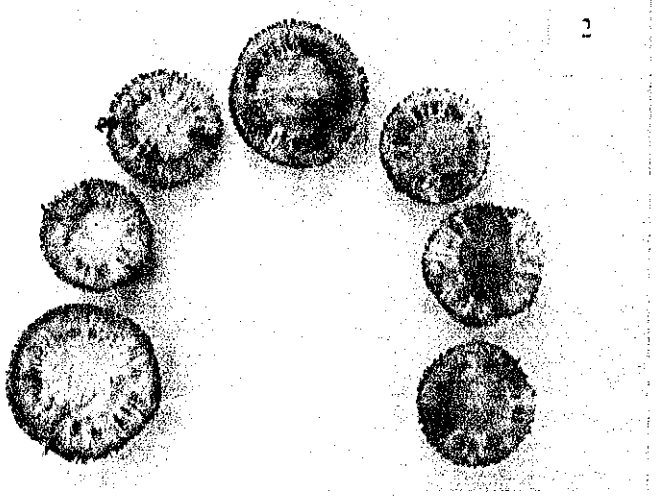


**Plate 13.** ***N. cadamba*** **fruits**

1. ***N. cadamba*** **fruits at different stages of their maturity (whole fruit)**
2. ***N. cadamba*** **seeds at different stages of their maturity (longitudinal section)**





## 2.4.5. *Tectona grandis*

### Seed collection areas

Seed trees were identified and marked in all the three Zones as given in Table 59.

**Table 59. Seed collection areas of *Tectona grandis* in Kerala**

| Seed zone | Sub-zone | Locality | Tree No. | GBH (cm) | Height (m) | Remarks |
|---|---|---|---|---|---|---|
| KL-1 | Konni | Aruvapalam | ATg-1 | 163 | 18 | |
| | | | ATg-2 | 158 | 31 | |
| | | | ATg-3 | 174 | 30 | |
| | | | ATg-4 | 200 | 31 | |
| KL-2 | Munnar | Karimutty | KTg-1 | 128 | 24 | |
| | | Alampetty | ATg-2 | 136 | 19 | |
| | | | ATg-3 | 096 | 11 | |
| | | | ATg-4 | 109 | 20 | |
| | | | ATg-5 | 144 | 17 | |
| | | | ATg-6 | 169 | 15 | |
| | | | ATg-7 | 108 | 10 | A1 and A2 are the bifurcated branches at the collar region |
| | | | ATg-8A1 | 104 | 15 | |
| | | | ATg-8A2 | 089 | | |
| | | | ATg-9 | 127 | 16 | |
| | | Churulipetty | CTg-10 | 123 | 13 | |
| | | | CTg-11 | 117 | 15 | |
| | | | CTg-12 | 132 | 15 | |
| | | | CTg-13 | 109 | 12 | |
| | | | CTg-14 | --- | --- | |
| | | | CTg-15 | 111 | 11 | |
| | | | CTg-16 | 108 | 12 | |
| | | | CTg-17 | 116 | 14 | |
| | | | CTg-A1 | 108 | 18 | |
| | | | CTg-A2 | 093 | -- | |
| | | | CTg-19 | 099 | 11 | |
| | | | CTg-20 | 135 | 16 | |
| | Malayattur | Malayattur | MTg-1 | 210 | 27 | |
| | | | MTg-2 | 225 | 27 | |
| | | | MTg-3 | 159 | 27 | |
| | | | MTg-4 | 184 | 24 | |
| | | Kannimangalam | KTg-1 | 157 | 21 | |
| | | | KTg-2 | 147 | 27 | |
| | | | KTg-3 | 134 | 26 | |
| | | | KTg-4 | 124 | 24 | |
| | | | KTg-4a | 190 | 21 | 4a denotes the tree is within 100m distance from the tree 4 |
| | | | KTg-5 | 160 | 22 | |
| | | | KTg-5a | 156 | 25 | |
| | | | KTg-6 | 171 | 29 | |
| | Chalakkudi | Vazhachal | VTg-1 | 080 | 18 | |
| | | | VTg-2 | 130 | 21 | |
| | | | VTg-3 | 169 | 24 | |
| | | | VTg-4 | 115 | 19 | |
| | Thrissur | Vettingapadam | VTg-1 | 115 | 15 | |
| | | | VTg-2 | 115 | 17 | |
| | | | VTg-3 | 162 | 29 | |
| | | | VTg-4 | 143 | 19 | |
| | | | VTg-5 | 157 | 29 | |
| | | KFRI. Peechi | KTg-1 | 175 | 29 | |
| | | | KTg-2 | 168 | 26 | |
| | | | KTg-3 | 117 | 28 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | KTg-4 | 116 | 18 | |
| | | | KTg-5 | 154 | 24 | |
| | | | KTg-6 | 135 | 20 | |
| | | | KTg-7 | 160 | 28 | |
| | | | KTg-8 | 180 | 24 | |
| KL-3 | Palakkad | Kuthiran | KTg-1 | 135 | 31 | |
| | | | KTg-2 | --- | --- | |
| | | Pothundi | PTg-1 | 134 | 17 | |
| | | | PTg-2 | 170 | 28 | |
| | | Kottathara | ATg-1 | 160 | 20 | |
| | | | ATg-1a | 134 | 20 | |
| | | Dhoni | DTg-1 | 132 | 17 | |
| | | | DTg-2 | 157 | 21 | |
| | | | DTg-3 | 110 | 20 | |
| | | | DTg-4 | 142 | 23 | |
| | | | DTg-5 | 159 | 21 | |
| | | | DTg-6 | 165 | 27 | |
| | | | DTg-7 | 185 | 33 | |
| | | | DTg-8 | 187 | 32 | |
| | | | DTg-9 | 242 | 28 | |
| | Nilambur | Nellikkuthu | NTg-1 | 156 | 35 | |
| | | | NTg-2 | 200 | 35 | |
| | | | NTg-3 | 200 | 34 | |
| | | | NTg-4 | 160 | 36 | |
| | | | NTg-5 | 200 | 45 | |
| | | Nedungayam | NTg-1 | 99 | 14 | |
| | | | NTg-2 | 183 | 25 | |
| | | | NTg-3 | 131 | 20 | |
| | | | NTg-4 | 120 | 22 | |
| | | | NTg-5 | 106 | 18 | |
| | | | NTg-6 | 107 | 19 | |
| | | | NTg-7 | 112 | 15 | |
| | | | NTg-8 | 114 | 15 | |
| | | | NTg-9 | 147 | 21 | |
| | | | NTg-10 | 129 | 25 | |
| | | | NTg-11 | 127 | 26 | |
| | | | NTg-12 | 94 | 20 | |
| | | | NTg-13 | 114 | 22 | |
| | | | NTg-14 | 112 | 18 | |
| | | | NTg-15 | 152 | 23 | |
| | | | NTg-16 | 126 | 17 | |
| | | | NTg-17 | 145 | 25 | |
| | | | NTg-18 | 145 | 20 | |
| | | | NTg-19 | 30 | 30 | |
| | | | NTg-20 | 101 | 20 | |
| | Wayanad | Kuppadi | KTg-1 | 195 | 13 | |
| | | | KTg-2 | 212 | 15 | |
| | | | KTg-3 | 208 | 20 | |
| | | | KTg-4 | 124 | 18 | |
| | | | KTg-5 | 138 | 20 | |

-- indicates data not available

ATg-1 Aruvapalam *Tectona grandis* tree number 1 ; KTg-1 Karimutty *Tectona grandis* tree number 1
ATg-1 Alampetty *Tectona grandis* tree number 1 ; CTg-10 Chirulipetty *Tectona grandis* tree number 10
MTg-1 Malayattur *Tectona grandis* tree number 1 ; KTg-1 Kannimangalam *Tectona grandis* tree number 1
VTg-1 Vazhachal *Tectona grandis* tree number 1 ; V Tg-1 Vettingapadam *Tectona grandis* tree number 1
KTg-1 KFRI *Tectona grandis* tree number 1 ; KTg-1 Kuthiran *Tectona grandis tree* number 1
PTg-1 Pothundi *Tectona grandis* tree number 1; ATg-1 Attapadi (Kottathara) *Tectona grandis* tree number 1
DTg-1 Dhoni *Tectona grandis* tree number 1 ; NTg-1 Nellikuthu *Tectona grandis* tree number 1
NTg-1 Nedungayam *Tectona grandis* tree number 1; KTg-1 Kuppadi *Tectona grandis* tree number 1

## Phenology of flowering and fruiting

Teak trees flower generally during June to August-September and fruits ripen from November to January. But an early flowering (May to July) was observed in almost all the zones and early fruit ripening occurred in Malayattur of Malayattur Sub-zone, Vettingapadam of Chalakkudi Sub-zone, Peechi of the Thrissur Sub-zone and Kakkupadi of Palakkad Sub-zone. Fruits were available until March in most of the Sub-zones except in Champakkad, Churulipetty and Karimutty of Munnar Sub-zone, where fruits are available for collection even in May. Details are given in Table 60.

**Table 60. Flowering and fruit collection period of *Tectona grandis* in Kerala**

| Zone | Sub-zone | Locality | Year | Flowering period | Fruit collection period | Seed crop* |
|---|---|---|---|---|---|---|
| KL-1 | Konni | Aruvapalam | 1998 | ----- | February | Good |
| KL-2 | Munnar | Champakkad | 1998 | ------ | February-May | Average |
| | | | 1999 | March | ----- | ---- |
| | | Churulipetty | 1998 | ----- | February-May | Average |
| | | | 1999 | March | ----- | ----- |
| | | Karimutty | 1998 | ----- | February- May | Average |
| | | | 1999 | March | ---- | |
| | Malayattur | Malayattur | 1998 | ------ | March | Poor |
| | | Kannimangalam | 1998 | ----- | September-December | Poor |
| | | | | | January-March | Average |
| | | | 1999 | May-July | | Average |
| | Chalakkudy | Vazhachal | 1998 | March | March. | Poor |
| | | Vettingapadam | 1998 | ----- | October- December | Average |
| | Thrissur | KFRI,Peechi | 1998 | April-July | September-December | Good |
| | | | | | January-early March | |
| | | | 1999 | May-mid July | --- | Good |
| | | | 2000 | March-June | --- | --- |
| | | Kuthiran | 1998 | Nil | Nil | Nil |
| | | | 1999 | Nil | Nil | Nil |
| KL-3 | Palakkad | Nelliampathy | 1998 | ----- | February | Average |
| | | Kakkupadi | 1998 | May- July | October-December | Good |
| | | | | | January-March | |
| | | | 1999 | ----- | Nil | Good |
| | | Dhoni | 1998 | ----- | Nil | Nil |
| | | | 1999 | ----- | January-March | Nil |
| | | Walayar | 1999 | ----- | | Good |
| | Nilambur | Nellikkuthu | 1998 | Nil | January-March | Good |
| | | | 1999 | Nil | Nil | Nil |
| | | Nedungayam | 1998 | Nil | Nil | Nil |
| | | | 1999 | Nil | Nil | Nil |
| | Wayanad | Kuppadi | 1999 | - | January-February | Good |

---not available

* refers to the seed crop at the time of collection.

## 2.4.5.1. Fruit collection and processing

Fruits were collected from the trees using a long pole and a hook and by manual shaking on a plastic sheet, which was spread around the tree. Fruits were loosely filled in a bag and vigorously rubbed to remove calyx from the fruits. Chaff was removed by winnowing.

**Fruit characteristics**

Fruit diameter with calyx varied from 0.9 to 2.3 cm and that without calyx, from 1 to 1.57 cm. Fruit length with calyx varies from 1 to 1.53 cm and without calyx from 1 to 1.44 cm (Plate 14). Indira *et al.* (1996) reported that most of the useful seeds (fruits without calyx) fall into the 0.9 to 1.8 cm category. In the present study, the highest fruit diameter obtained without calyx was 15.7 mm and with calyx was 23 mm. The details are given in Table 61.

**Table 61. Fruit characteristics of *Tectona grandis***

| Locality | Tree No. | Date of collection | Fruit measurement with calyx (cm) | | Fruit measurement without calyx (cm) | |
|---|---|---|---|---|---|---|
| | | | Length | Breadth | Length | Breadth |
| Karimutty | KTg-9 | 05/02/98 | 2.11 (0.05) | 1.53 (0.05) | 1.50 (0.03) | 1.44 (0.05) |
| Pothundy | PTg-1 | 18/02/98 | 1.15 (0.16) | 1.55 (0.51) | 1.34 (0.04) | 1.13 (0.09) |
| " | PTg-2 | " | 2.30 (0.06) | 1.85 (0.32) | 1.57 (0.14) | 1.42 (0.13) |
| Aruvapalam | ATg-1 | 06/03/98 | 1.50 (0.14) | 1.31 (0.11) | 1.14 (0.21) | 1.3 (0.26) |
| " | ATg-2 | " | 1.05 (0.02) | 1.05 (0.02) | 1.01 (0.005) | 0.97 (0.01) |
| " | ATg-3 | " | 1.20 (0.06) | 1.09 (0.1) | 1.13 (0.11) | 1.03 (0.10) |
| " | ATg-4 | " | -- | -- | 1.05 (0.04) | 1.20 (0.03) |
| Neilikkuthu | NTg-1 | 26/03/98 | 1.28 (0.13) | 1.15 (0.07) | 1.28 (0.12) | 1.13 (0.01) |
| " | NTg-2 | " | 1.00 (0.04) | 1.29 (0.10) | 1 (0.13) | 1 (0.10) |
| " | NTg-3 | " | 1.31 (0.15) | 1.00 (0.11) | 1.22 (0.04) | 0.94 (0.03) |
| " | NTg-4 | " | 1.36 (0.18) | 1.04 (0.15) | 1.24 (0.15) | 0.94 (0.07) |
| " | NTg-5 | " | 1.8 (0.18) | 1.13 (0.06) | 1.14 (0.08) | 1.32 (0.04) |
| Champakkad | CTg-2 | 26/05/98 | 1.32 (0.21) | 1.55 (0.11) | 1.08 (0.03) | 1.11 (0.06) |
| Karimutty | KTg-9 | 26/05/98 | 1.78 (0.23) | 1.41 (0.08) | 1.28 (0.13) | 1.25 (0.05) |
| Champakkad | CTg-13 | ,, | 1.64 (0.52) | 1.28 (0.12) | 1.22 (0.02) | 1.10 (0.02) |
| Churulipetty | CTg-19 | 27/05/98 | 1.84 (0.09) | 1.22 (0.02 | 1.13 (0.01) | 1.09 (0.09) |
| " | CTg-20 | " | 1.69 (0.13) | 1.17 (0.04 | 1.11 (0.12) | 1.17 (0.07) |
| Pooled mean | | | 1.52 (0.38) | 1.27 (0.23) | 1.20 (0.15) | 1.15 (0.15) |

(Figures in parentheses indicate S.E. of Mean value)

Number of locules per fruit vary from 2 to 4. Prasad and Kandya (1992) reported that each fruit has four locules. But there are single loculed, two loculed as well as three loculed fruits. Numbers of sound seeds per fruit vary from 0 to 2 and empty locules per fruit vary from 1.2 to 2.7. Details are given in Table 62.

**Table 62. Fruit characteristics of *Tectona grandis***

| Zone | Sub-zone | Locality | Tree No. | Date of collection | Mean number of | | |
|---|---|---|---|---|---|---|---|
| | | | | | Locules per fruit | Sound seeds per fruit | Empty locules per fruit |
| KL-2 | Munnar | Karimutty | KTg-9 | 06/03/98 | 3.4 (0.96) | 0.7 (0.67) | 2.6 (1.07) |
| KL-3 | Palakkad | Pothundy | PTg-1 | 18/02/98 | 3.54 (0.68) | 0.27 (0.46) | 1.63 (1.68) |
| " | " | " | PTg-2 | " | 3 (1.09) | 0.54 (0.68) | 2.36 (1.12) |
| KL-2 | Konni | Aruvapalam | ATg-1 | 06/03/98 | 3.1 (1.10) | 0.4 (0.05) | 2.7 (1.49) |
| " | " | " | ATg-2 | " | 3.4 (0.84) | 1.2 (1.3) | 2.3 (1.32) |
| " | " | " | ATg-3 | " | 3.5 (0.84) | 0.9 (1.37) | 2.3 (1.25) |
| " | " | " | ATg-4 | " | 3.3 (1.10) | 1 (0.86) | 1.6 (0.84) |
| KL-3 | Nilambur | Nellikkuthu | NTg-1 | 26/03/98 | 3.4 (0.69) | 0.7 (0.67) | 1.6 (1.50) |
| " | " | " | NTg-2 | " | 3.2 (0.91) | 0.7 (0.67) | 1.2 (1.22) |
| " | " | " | NTg-3 | " | 3.5 (0.07) | 0.5 (0.52) | 2.81 (0.78) |
| " | " | " | NTg-4 | " | 3.3 (1.15) | 0.8 (0.91) | 2.3 (1.48) |
| KL-3 | Munnar | Churlipetty | CTg-20 | 27/05/98 | 3.81 (0.40) | 0.90 (0.94) | 2.54 (1.36) |
| " | " | Champakkad | CTg-2 | 26/05/98 | 2.3 (0.94) | 0 | 1.7 (0.92) |
| " | " | " | CTg-13 | 26/05/98 | 3.5 (0.84) | 1.66 (0.70) | 1.2 (1.03) |
| | " | Churulipetty | CTg-19 | 27/05/98 | 2.9 (0.99) | 0.79 (0.67) | 2.2 (1.22) |
| Over all mean | | | | | 3.27 (0.34) | 0.73 (0.39) | 2.00 (0.57) |

(Figures in parentheses indicate S. E. of Mean value)

Prasad and Kandya (1992) reported 1500 to 2500 number of seeds per kg. In Nellikkuthu plantation in Nilambur, number of seeds per kg among trees (5 trees) varied from 1900 to 2600 between trees. In Aruvapalam Plantation in Konni, the number of seeds per kg varied from 1700 to 3100 in 4 trees. In Pothundi of Palakkad Sub-zone seeds per kg between 4 trees varied from 1600 to 2500. In Churulipetty of Munnar Sub-Zone seeds per kg between trees (4 trees) varied from 1700 to 2200. Karimutty, Aruvapalam and Churulipetty belong to the same Sub-Zone and within the same Sub-zone seeds per kg varied from 1200 to 3100. Large sized seeds were

obtained from Karimutty (270 per litre) and the smallest seeds from Aruvapalam (1250 per litre). And weight of 1000 seed varied from 382g (Aruvapalam) to 681g (Karimutty). Details are given in Table 63.

**Table 63. Table showing teak seeds per kg and litre**

| Zone | Sub-zone | Locality | Tree number | Seeds/kg | Seeds/litre | 1000 seed weight (g) |
|---|---|---|---|---|---|---|
| KL-3 | Palakkad | Pothundi | PTg-1 | 2515 | 783 | 427.35 |
| ,, | ,, | ,, | PTg-2 | 1633 | 503 | 561.77 |
| KL-2 | Konni | Aruvapalam | ATg-1 | 1723 | 670 | 639.512 |
| ,, | ,, | ,, | ATg-2 | 3078 | 1258 | 382.68 |
| ,, | ,, | ,, | ATg-3 | 2658 | 718 | 683.36 |
| ,, | ,, | ,, | ATg-4 | 1952 | 613 | 488.56 |
| KL-3 | Nilambur | Nellikkuthu | NTg-1 | 1891 | 630 | 479.25 |
| ,, | ,, | ,, | NTg-2 | 2435 | 840 | 408.46 |
| ,, | ,, | ,, | NTg-3 | 2282 | 835 | 414.28 |
| ,, | ,, | ,, | NTg-4 | 2411 | 863 | 399.63 |
| ,, | ,, | ,, | NTg-5 | 2594 | 1008 | -- |
| KL-2 | Munnar | Karimutty | KTg-9 | 1262 | 270 | 681.57 |
| ,, | ,, | Churulipetty | CTg-20 | 2084 | 918 | -- |
| ,, | ,, | Champakkad | CTg-2 | 2221 | 318 | -- |
| ,, | ,, | Churulipetty | CTg-19 | 1783 | 520 | -- |
| ,, | ,, | Champakkad | CTg-13 | 2145 | 730 | -- |
| Pooled mean | | | | 2122.7 (476.09) | 709.058 (244.36) | 478.766 (105.02) |

-- data not available
(Figures in parentheses indicate S.E. of Mean value).

## 2.4.5.2. Influence of sub-zone and tree variation on germination

There is considerable variation of seed germination percentage between zones and trees within same zone as revealed from the Table 64. In Aruvapalam of Konni Sub-zone, the percentage of sound seeds in a sample varies from 40 to 70 out of which 12.5 to 55% germinated. In Churulipetty of Munnar Sub-zone percentage of sound seeds varied from 60 to 100, but none geminated. In Nellikkuthu plantation of Nilambur Sub-zone, percentage of sound seeds varied from 50 to 60 and 48 to 60% germinated. In Pothundi of Palakkad Sub-zone, the pecentage of sound seed varied from 27 to 50; 44 to 67% of them germinated.

**Table 64. Germination of teak seeds collected from different zones as well as different trees in the same locality**

| Zone | Sub-zone | Locality | Tree number | Number of days taken between collection and sowing | MC % of seeds at the time of sowing | % of germination at 45 DAS | Number of days taken for commencing germination | Percentage of sound seeds in the sample | Germination as percentage of viable seeds (%) |
|---|---|---|---|---|---|---|---|---|---|
| KL-1 | Konni | Aruvapalam | ATg-1 | 210 | 9.22 (0.168) | 54 | 12 | – | – |
| | | | ATg-2 | | 8.95 (0.094) | 33 | 12 | 60 | 55.8 |
| | | | ATg-3 | | 10.56 (1.198) | 5 | 14 | 40 | 12.5 |
| | | | ATg-4 | | 11.495 (0.755) | 16 | 13 | 70 | 22.9 |
| KL-2 | Munnar | Churulipetty | CTg-19 | 150 | 10.666 (0.108) | 0 | - | 100 | 0 |
| | | | CTg-20 | | 10.932 (0.342) | 0 | - | 60 | 0 |
| KL-3 | Nilambur | Nellikkuthu | NTg-1 | 210 | 11.12 (1.465) | 29 | 11 | 60 | 48.3 |
| | | | NTg-2 | | 11.59 (0.406) | 48 | 12 | 60 | 80 |
| | | | NTg-3 | | 11.55 (0.628) | 40 | 12 | 50 | 80 |
| | | | NTg-4 | | 10.589 (0.509) | 38 | 12 | 50 | 76 |
| KL-3 | Palakkad | Pothundi | PTg-1 | 226 | 14.648 (1.065) | 18 | 16 | 27 | 66.7 |
| | | | PTg-2 | | 13.103 (0.200) | 22 | 16 | 50 | 44 |

(Figures in parentheses S. E. of Mean value)

## 2.4.5.3. Source variation and germination

There was considerable variation in germination of seeds collected in 1998-1999 from different sources. Seeds collected from Kuppadi gave maximum percent germination (30.25). The details are given in Table 65.

**Table 65. Germination of teak seeds collected from different sources**

| Source Code | Seed zone | Sub-zone | Locality | Date of collection | MC % of seed | % of germination at 45days after sowing | Number of days taken for commencing germination |
|---|---|---|---|---|---|---|---|
| S1 | KL-2 | Munnar | Karimutty | 06/03/98 | 12.38 (0.07) | 0.25 | 34 |
| S2 | ,, | ,, | ,, | 03/03/99 | 15.2 (0.14) | 26.75 | 15 |
| S3 | KL-3 | Wayanad | Kuppadi | 06/01/99 | 13.31 (0.07) | 30.25 | 13 |
| S4 | ,, | ,, | ,, | 25/02/99 | 12.78 (0.10) | 1.5 | 17 |
| S5 | ,, | Palakkad | Kakkupadi | 26/11/98 | 14.44 (0.49) | 0 | -- |
| S6 | ,, | ,, | ,, | 19/02/99 | 13.99 (0.15) | 0.75 | 21 |
| Over all mean | | | | | 13.68 (1.06) | 9.791 (14.09) | 20 (8.366) |

-- data not available
(Figures in parentheses indicate S.E. of Mean value).

## 2.4.5.4. Seed pathology of *T. grandis*

Dry seed examination Teak seeds (fruits) collected from all the three localities viz., Wayanad, Nilambur, and Chinnar were found to be severely infested by insects, which made tunnels in the mesocarp and endocarp from the pedicel part of the fruit. Insect infestation ranged from 9 to 18.5 percent and the highest attack was observed on seeds from Wayanad. Fungal hyphae, fructifications and sclerotia were also observed on the fruits. Discolouration and shriveling were associated with about 12.5% of the seeds from Chinnar. Results on extraction of seeds from teak fruits revealed that empty locules were very common in teak fruits from Chinnar. Moreover, ill-filled and shriveled seeds were more in seed samples from Chinnar than from the other two localities. Seeds inside the locules were also found deteriorated and covered with fungal mycelium.

**Seed microflora**

Employing blotter and agar plate methods, a rich microflora comprising 18 fungal genera, together with mycelia sterilia (black and white coloured mycelia),

bacteria and actinomycetes were detected on seeds of *Tectona grandis* from different localities (Table 66-68). Of these, seeds from Wayanad harboured more number of microorganisms and also showed their highest frequency of occurrence. The most frequent fungal genera were *Aspergillus*, (represented by three species) *Botryodiplodia*, *Fusarium,* (represented by three species) and *Trichoderma* (Table 66--68) Though, bacteria were found in all the three seedlots tested, their highest frequency (33%) was observed in seeds from Wayanad. As expected, number of microorganisms and their percent incidence were higher in unsterilized seeds (NSS) than surface sterilized (SS), and acid treated (A) seeds. By surface sterilization, most spermoplane microflora except bacteria were excluded. Sulphuric acid treatment was also equally effective in reducing the seed microflora substantially and increasing the percent germinability of the seeds. Emerging seedlings in these treatments were found very healthy and showed no sign of seedling infection caused by storage or field fungi.

Seed health test by agar plate method, where extracted seeds were used, revealed association of field fungi like *Botryodiplodia theobromae*, *Fusarium moniliforme*, *Curvularia lunata, Phoma* sp., *Colletotrichum gloeosporioides*, etc. in all the three seedlots tested. Of these, many are capable of causing seedling rot and foliage infection. The high level of infestation of the teak seeds by these field fungi clearly indicates the possibility of infection by the pathogen during the early developmental phase of the fruits.

**Growing-on test**

Seedling emergence started four to six days after sowing in the sterile perlite medium and continued up to 21 days. However, a large number of them emerged within 8 to 12 days of sowing. Percentage germination was slightly higher (51%) than that obtained in blotters. Seedling infection viz. damping-off, collar rots, cotyledon rot, etc. were observed on the emergents. Isolations made from the diseased specimens yielded *Fusarium moniliforme, F. oxysporum* and *Curvularia lunata.*

**Seed pre-treatment**

The percent germination of seeds from the different localities viz. Wayanad, Nilambur and Chinnar ranged from 36 to 48 in blotter test. Soaking the seeds in concentrated sulphuric acid for 20 min gave higher percent germination (Table 69).

Of the three seed lots tested, highest germination of 78% was obtained for seeds from Nilambur, followed by seeds from Chinnar (74%).

**Table 66. Spermoplane microorganisms detected on seeds of *T. grandis* Wayanad 1998 seedlot) by blotter and agar plate method**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method % incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Alternaria alternata* | 2 | | | 2 |
| 2 | *Aspergillus* spp. | 1 | | | |
| 3 | *Aspergillus niger* | 16 | 1 | 4 | 4 |
| 4 | *Botryodiplodia theobromae* | 2 | | | 4 |
| 5 | *Chaetomium* sp. | 3 | | | |
| 6 | *Colletotrichum gloeosporioides* | 6 | | | |
| 7 | *Curvularia* sp. | | | | 4 |
| 8 | *Drechslera* sp. | 1 | | | |
| 9 | *Fusarium* sp. | 20 | | | 12 |
| 10 | *Mucor* sp. | | | 14 | |
| 11 | *Paecilomyces* sp. | 8 | | | |
| 12 | *Penicillium* sp. | 7 | | | |
| 13 | *Pestalotia* sp. | 4 | | | |
| 14 | *Phomasp* sp. | 5 | 4 | | |
| 15 | *Trichoderma* sp. | 12 | 4 | 4 | |
| 16 | *Verticillium* sp. | 3 | | | |
| 17 | Sterile mycelium (black) | | 8 | 8 | 2 |
| 18 | Sterile mycelium (white) | 2 | | | |
| 19 | Bacteria | 33 | 10 | 6 | 8 |
| 20 | Actinomycetes | 1 | | | |

*NSS: non-surface sterilized; SS: surface sterilized; A: sulphuric acid treatment

**Table 67. Spermoplane microorganisms detected on seeds of *T. grandis* (Chinnar 1998 seedlot) by blotter and agar plate methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method % incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Aspergillus* sp. | 10 | | 6 | 8 |
| 2 | *Aspergillus niger* | 9 | 1 | | 4 |
| 3 | *Beltrania* sp. | 3 | | | |
| 4 | *Botryodiplodia theobromae* | 4 | | | 1 |
| 5 | *Chaetomium* sp. | 6 | | | 2 |
| 6 | *Curvularia* sp. | 2 | | | 2 |
| 7 | *Drechslera* sp. | 2 | | | |
| 8 | *Fusarium* sp. | | | | 4 |
| 9 | *Penicillium* sp. | 5 | | | 6 |
| 10 | *Pestalotia* sp. | 2 | | | |
| 11 | *Phoma* sp. | 4 | | | 2 |
| 12 | *Trichoderma* sp. | | 8 | 4 | |
| 13 | *Verticillium* sp. | 1 | | | |
| 14 | Sterile mycelium (black) | 1 | | | 2 |
| 15 | Sterile mycelium (White) | | | 8 | |
| 16 | Bacteria | 7 | 6 | 18 | |
| 17 | Actinomycetes | | | | 2 |

*NSS: non-surface sterilized; SS: surface sterilized: A: sulphuric acid treatment

**Table 68. Spermoplane microorganisms detected on seeds of *T. grandis* (Nilambur 1998 seedlot) by blotter and agar plate methods and their percent incidence**

| Sl. No. | Microorganism | Blotter method % incidence | | | Agar plate method % incidence |
|---|---|---|---|---|---|
| | | NSS* | SS | A | |
| 1 | *Aspergillus* sp. | 7.00 | | | 10.00 |
| 2 | *Aspergillus niger* | | | | 2.00 |
| 3 | *Botryodiplodia theobromae* | 4.00 | | | 4.00 |
| 4 | *Cephalosporium* sp. | 2.40 | 6.00 | | 3.00 |
| 5 | *Colletorichum gloeosporioides* | | | | 2.00 |
| 6 | *Curvularia* sp. | 10.00 | | | 2.00 |
| 7 | *Drechslera* sp. | 3.20 | | | |
| 8 | *Fusarium* sp. | 4.40 | | | 6.00 |
| 9 | *Mucor* sp. | 5.60 | | | |
| 10 | *Paecilomyces* sp. | 3.20 | | | 2.00 |
| 11 | *Penicillium* sp. | 9.60 | | | 3.00 |
| 12 | *Pestalotia* sp. | 2.80 | | | |
| 13 | *Phoma* sp. | 4.80 | 1.00 | | 4.00 |
| 14 | *Trichoderma* sp. | 6.00 | 4.00 | 4.00 | 6.00 |
| 15 | *Trichothecium* sp. | 1.20 | | | |
| 16 | Sterile mycelium (black) | 3.20 | 8.00 | 4.00 | 6.00 |
| 17 | Sterile mycelium (White) | | | 10.00 | |
| 18 | Bacteria | 10.40 | 8.00 | 20.00 | 10.00 |

*NSS: non-surface sterilized; SS: surface sterilized; A: acid treatment

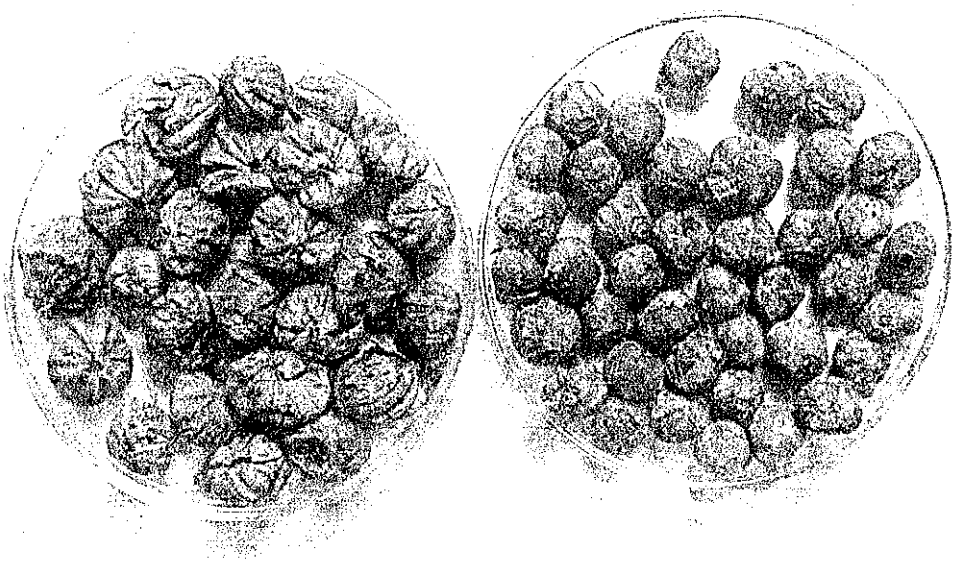
**Table 69. Effect of various seed pre-treatments on percent germination of *T. grandis* seeds collected from different localities of the State**

| Percent seed germination | | | | | |
|---|---|---|---|---|---|
| Locality | Zone | Sub zone | NSS | SS | A |
| Wayanad | KL-3 | C | 46 | 40 | 64 |
| Chinnar | KL-2 | B | 48 | 34 | 74 |
| Nilambur | KL-3 | C | 39 | 36 | 78 |

*NSS: non surface sterilized; SS: surface sterilized; A: sulphuric acid treatment

**Plate 14. *T. grandis* seeds**

**(a). with calyx** **(b). without calyx**



## 4. References cited in Results


Beniwal, B. S. and Dhawan, V.K. 1991. Standardisation of nursery technique of *Anthocephalus chinensis*. Indian Forester 117(2): 105-109.

FRI 1983. Troup's The Silviculture of Indian trees Volume 4. (ed. Editorial Board, Forest research institute and colleges, Dehra Dun). Controller of publications, Delhi, 335p.

Hocking, D. 1993. Trees for dry lands. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 339p.

Indira, E.P., Chacko K.C., Krishnankutty, C.N., 1996. Studies on growth performance of teak nursery stock from genetically better sources for developing improved plantations. KFRI Research Report 102. Peechi, Trichur, India: Kerala Forest Research Institute.

Lowry, J.B. Prinsen, J.H. and Burrows, D. M. 1994. Albizia lebbeck- a promising forage tree for semiarid regions. In: Gutteridge R C, Shelton H. M. eds. Forage Tree legumes in tropical agriculture, Wallingford, U.K. CAB International. 75-83p.

Palani, M., Dasthagir, M.G. and Kumaran, K. 1995. Effect of different pre-sowing treatments on germination and seedling growth in *Acacia nilotica*. International Tree Crops Journal 8(2-3): 189-192.

Prasad R., Kandya, A.K, 1992. Handling of Forestry Seeds in India. New Delhi, India: Associated Publishing Company, 420p.

## 2.5. ABSTRACT OF SIGNIFICANT FINDINGS

Major findings of the study are summarised below for each species.

### 2.5.1. *Acacia nilotica*

In Kerala, *A. nilotica* seed trees are available in zones 2 and 3 and not in zone 1. They are available at Kottathara, Walayar, Meenakshipuram (Zone-KL-3, Sub-zone-Palakkad) and Chinnar (Zone-KL-2, Sub-zone-Munnar). Tallest tree in the study area had a height 19.9 m [Meenakshipuram (MAn-19)] and the maximum girth measured was 206 cm for a tree at Walayar (KPLAn-3). Seeds ripen from March to May and pods can be collected during this period. Seeds can be extracted from pods either after air-drying, sun-drying or oven-drying and with the help of a motorised drum type seed scarifier. Seeds are separated from the chaff by sieving through a sieve of 5 mm mesh size. There are 5900-6500 seeds in a kg. Oven-drying enhances germination. Seeds germinate well under partial light and under dark also. On the other hand, full light has an inhibitory effect on germination. Pre-sowing treatment with sulphuric acid for 1 hour followed by soaking in 0.2% $KNO_3$ or 2% thiourea improves germination. For germination test, rolled towel is the better medium compared to quartz sand.

Seeds of *A. nilotica* harbour a rich microflora comprising 18 fungal genera, mycelia sterilia, bacteria and actinomycetes. Among storage fungi, *Aspergillus* spp., *Penicillium* spp. and *Trichoderma* spp. are the predominant ones. *Beltrania* sp., *Botryodiplodia theobromae*, *Colletotrichum gloeosporioides*, *Coniella* sp., *Drechslera* sp., *Fusarium* sp. and *Phoma* sp. are the important field fungi recorded on seeds from all the three localities. Surface sterilization of seeds with

0.01% mercuric chloride excludes most of the spermoplane microorganisms and their number was reduced to 5-7 and the percent incidence was very less. Similarly, pre-sowing treatments using cold water, hot water, and sulphuric acid help to exclude most spermoplane microflora from all the three seed samples. Agar plate method, in which surface sterilized seeds were plated on potato dextrose agar medium yielded comparatively a few spermoplane microbes. Field fungi like *Fusarium* sp., *Coniella* sp. *Beltrania* sp., *Curvalaria* sp., *Phoma* sp., etc. were detected by this method. In blotter test and agar plate method, seeds severely infested with *Fusarium* spp. exhibited seed rot and emerging seedlings from such seeds became infected by the fungus.

### 2.5.2. *Albizia lebbeck*

*A. lebbeck* is a large deciduous tree sparsely distributed in the dry deciduous (Chinnar) and moist deciduous (Peechi and Nilambur) forests of Kerala. It is grown in avenues (Palakkad and Kuzhalmandam and Meenakshipuram), and gardens. Seed trees were identified in two zones (KL-2 and 3). In KL-2 zone, seed trees are located at Olamattam, Champakkad, Churulipetty, Karimuttty and Alampetty (Munnar Sub-zone), Malayattur (Malayattur Sub-zone), Vazhachal and Amballur (Chalakkudi Sub-zone). In KL-3 zone, seed trees are available at Peechi (Thrissur Sub-zone), Kuzhalmandam, Malampuzha, Meenakshipuram and Kottathara (Palakkad Sub-zone) and Kuppadi (Wayanad Sub-zone). The largest tree located at Meenakshipuram had a height 44 m and a girth of 6.2m for a tree, which is much more than an earlier report of 4.52 m, mentioned in FRI (1983). A noticeable tree to tree variation was observed

within the species in season of flowering and fruit ripening. Pod collection period is from November to March in Kuzhalmandam, Chandranagar, Olamattom and Karimutty whereas it is from February to May in Alampetty, Churulipetty, Karimutty and Kottathara. Of the five different methods tried for seed extraction, oven-drying of pods at 45°C for 24 hours after water spraying, gave maximum dehiscence. For small samples it is easy to extract the seeds from partially dehisced pods by hand. Seeds could also be extracted from pods, using a seed scarifier. There are 6250-12210 seeds in a kg. Pre-sowing treatment is required for the germination of *A. lebbeck* seeds. Treatment using concentrated sulphuric acid for 35 minutes yields best rresult. Seed germination occurs within 7 days after sowing and seedlings produce first pair of leaves within 25 days. Pre-sowing treatment with sulphuric acid for longer duration (50 minutes or more) although improves germination, is detrimental to seedlings emerging from such seeds as the seedlings in such cases had curled leaves and abnormal root system. There is variation in germination of seeds collected from the same Sub-zones. Among the five media tried, sowing the seeds between-papers gave better germination than top of paper, vermiculite, rolled towel and quartz sand. Quartz sand is the next best medium in the nursery condition. Seed germination was unaffected by light conditions. However light is needed immediately after germination for photosynthesis.

A rich microflora comprising 19 fungal genera, together with unidentified mycelia sterilia, bacteria and actinomycetes were encountered on seeds of *Albizia lebbeck* collected from the three different agroclimatic sub-zones of the State. Seed health test by blotter method revealed a large number of spermoplane microbes on

unsterilized seeds. Among the seedlots tested, those from Palakkad recorded more number of spermoplane microbes, which include common storage moulds, field fungi, bacteria and actinomycetes. Among the storage moulds, *Aspergillus spp.*, *Chaetomium* sp., *Rhizopus* sp., *Penicllium* sp., etc. were the predominant fungi. Their frequency of occurrence ranged from 21-48%. Among the field fungi recorded on seeds, *Beltrania* sp., *Colletotrichum gloeosporioides*, *Fusarium* sp. and *Phoma* sp. are the important ones and their percent incidence in the seed samples from the three localities ranged from 7 to 21. Incidence of bacteria in seeds ranged from 7 to 19% in unsterilized seed samples. Bacteria were found mostly associated with the discoloured and deformed seeds and such seeds become completely rotten with heavy bacterial ooze. Though, surface sterilization with 0.01% mercuric chloride reduced the per cent incidence of the bacteria, both hot water and acid treatment increased the per cent incidence.

### 2.5.3. *Dalbergia sissoides*

*D.sissoides* is a medium sized deciduous tree found in the moist deciduous forests of Kerala especially in very moist teak forests (Karulai and Dhoni) and mixed deciduous forests (Sholayur, Chinnar and Kuppadi). Seed trees were identified in all the three zones (KL-1, KL-2 and KL-3). In Zone 1 the seed trees were located at Ezhukumannu (Kottayam Sub-zone). In zone 2 trees were located in Malayattur (Malayattur Sub-zone); Champakkad and Churulipetty (Munnar Sub-zone), KFRI and Kuthiran (Thrissur Sub-zone), Vettingapadam (Chalakkudi Sub-zone). In zone 3 trees were located in Dhoni, Thavalam, Kakkupadi, Sub-zone). The maximum tree

height (37 m) was recorded for a tree at Dhoni and maximum gbh (2.72 m) was measured for a tree at Mundakkadavu. Flowering occurs during December to January in Peechi and during February in Kuppadi and Dhoni. Early February is the best time for the collection of pods. At Champakkad, mature fruits were available during the month of April. Light brown pods are collected from the trees preferably early in the morning, especially in areas where chances of pods being blown away by wind are high. Plastic sheets are spread around the tree to make the collection easier. Seeds are extracted from pods using a seed scarifier (Agrosaw- electric) after oven-drying at 50°C for three hours. If the pods are brittle, oven-drying is not necessary. There are 26,300-45,500 seeds in a kg of this seeds collected from Peruvaripallam were especially larger and those from a tree in Peruvaripallam were the smallest (40000-45500 seeds in a kg). Rolled towel is the best medium for the germination of seeds in the laboratory condition. Partial light favours seed germination. Germination is better for large sized seeds.

A rich microflora comprising 16 fungal genera, together with mycelia sterilia, bacteria and actinomycetes were detected on seeds of *D. sissoides* collected from different localities. Most microorganisms were encountered on un sterilized seeds in blotter tests. Among the seedlots, those from Wayanad and Dhoni harboured more number of spermoplane microbes than the seeds from Chinnar. The spermoplane microbes detected include the common storage fungi, field fungi, bacteria and actinomycetes. Among the storage fungi, *Aspergillus* spp., *Penicilium* spp. and *Chaetonimum* sp. were the predominant ones. The incidence of these storage fungi ranged from 38 to 69%. However, the occurrence of field fungi like *Alternaria*

sp., *Curvularia* sp., *Drechslera* sp., *Bipolaris* sp., *Fusarium* spp., *Pestalotia* sp., *Phoma* sp., etc. in all the three lots ranged from 4-41%. As expected, the fungal genera, their frequency of occurrence as well as intensity of infestation were more in unsterilized seeds from all the three localities. Surface sterilization of the seeds with 0.01% mercuric chloride considerably reduced the occurrence of the fungal genera to 1-3 and also the percent incidence to 6-10. Even though, bacteria were detected on seeds from all the three localities, their incidence was substantially reduced by surface sterilization and also by other seed pre-treatments. Cold water, hot water, and acid treatments carried out to enhance the seed germinability, were also effective in excluding most of the spermoplane microflora. Seed health test employing agar plate method could detect a large number of field fungi like *Colletotrichum gloeosporioides, Curvularia* sp., *Fusarium pallidoroseum, Phoma* sp., *Pestalotia* sp., etc. Of these *C. gloeosporioides* was encountered in high frequency on seeds from Wayanad (25%) and Dhoni (10%). Many of these field fungi are potential pathogens of *Dalbergia sissoides* seedlings in nurseries. The results indicate that at least a few of these fungi which are possibly seed-borne may play a role in deterioration of seeds in storage as well as incidence of seedling diseases in nurseries.

### 2.5.4. *Neolamarckia cadamba*

In Kerala *N. cadamba* grows in moist deciduous and semi evergreen forests of Dhoni, Nilambur, Wayanad and Konni near and along streams. At Kannimangalam in Malayattur Forest Division, the Forest Department grows this species as a plantation crop on a small area. Seed trees were identified at all the three zones. Tallest tree is

recorded at Mukkali (45m) and that with largest gbh (328cm) at Vayakkara in Konni Sub-zone. In Kerala, seed collection period is August-November. In Nilambur, fruits are available from early August to November. At Kannimangalam, Wayanad and Irinjalakkuda, fruits are available from September to mid-November. Peak period of collection is in September. It is important that fruits falling from the trees are collected every day, as animals eat the fruits. If the trees are too tall, seeds can only be collected from forest floor. Seeds can be extracted from fruits both by dry and wet. In dry method, ripe fruits are sun-dried until they became brittle, and then the seeds are extracted by rubbing the brittle fruits on a metal grating and sieving through a 0.5mm sieve. In wet method seeds are extracted by crushing the rotten fruits in a bucket of water and making slurry of it. By repeated decantation followed by filtration floater and sinker seeds are separated .The seeds are sun-dried and winnowed to separate the chaff. Wet method is the best method of extraction compared to dry method in terms of purity of seeds. However wet method of extraction is time consuming and labour intensive. There are 2,30,00,000 to 3,12,50,000 seeds in a kg. Seeds collected during November gave maximum germination. Polyurethane sheet is an approximate medium for germination of seeds especially in the laboratory. Exposure of seeds to different light conditions (viz., full light, partial light and zero light) in nursery and in laboratory confirms the need of good light condition for germination of *N. cadamba* seeds. Of the colour stages of maturity, fruits containing brown seeds especially those from cactus green fruits gave maximum germination.

Seeds from all the four localities in the State showed comparatively a poor microflora represented by 2 to 3 fungal genera belonging to the group of storage fungi

and about 5 field fungi. The percent incidence of all the spermoplane microbes was also less and ranged from 1 to 8. *Aspergillus* spp. *Chaetomium* sp., *Mucor* sp. and *Trichoderma* sp. were the storage fungi encountered while, *Colletotrichum gloeosporioides, Drechslera* sp., *Fusarium* sp. *Pestalotia* sp. and *Phoma* sp. were the field fungi recorded. Association of bacteria and their percent incidence were also less and ranged from 3 to 4 in all the treatments. Seed pre-treatment with sulphuric acid to enhance the germination also helped in removing the spermoplane fungal flora. The treatment was highly effective and no fungal flora except sterile mycelium was observed on treated seeds. Agar plate method also yielded only a few fungal species from the seedlots from different localities. *Fusarium oxysporum* and *Phoma* sp., were the important field fungi probably seed-borne found associated with the seeds.

### 2.5.5. *Tectona grandis*

Teak is available in all the three seed zones. Among these in plantations, the maximum tree height (35 m) was measured for two trees at Nellikkuthu and maximum gbh (225 cm) was measured for a tree at Malayattur. Teak flowers generally during June to August or September. But an early flowering is also observed in almost all the zones (May to July). Generally fruits ripen from November to January. But an early fruit ripening was observed in Malayattur of Malayattur Sub-zone, Vettingapadam of Chalakkudi Sub-zone, Peechi of the Thrissur Sub-zone and Kakkupadi of Palakkad Sub-zone. Fruits are available until March in all the Sub-zones but in Champakkad, Churulipetty and Karimutty of Munnar Sub-zone, fruits are available for collection even in May. There is considerable variation in germination of

seeds collected from different sources. Seeds collected from Kuppadi (Wayanad) gave maximum germination.

A rich microflora comprising 18 fungal genera, together with mycelia sterilia, bacteria and actinomycetes was detected on seeds of *Tectona grandis* from different localities. Of these, seeds from Wayanad harboured more number of microorganisms as well as showed their highest frequency of occurrence. The most frequent fungal genera were *Aspergillus*, *Botryodiplodia*, *Fusarium,* and *Trichoderma.* As expected, number of microorganisms and their percent incidence were higher in unsterilized seeds (NSS) than surface sterilized (SS), and acid treated (A) seeds. Sulphuric acid treatment was effective in reducing the seed microflora substantially and increasing the percent germinability of the seeds. Emerging seedlings in these treatments were found very healthy and showed no sign of seedling infection. Seed health test by agar plate method, where extracted seeds were used, revealed association of field fungi like *Botryodiplodia theobromae*, *Fusarium moniliforme*, *Curvularia lunata, Phoma* sp., *Colletotrichum gloeosporioides*, etc. in all the three seedlots tested. Of these, many are capable of causing seedling rot and foliage infection. The high level of infestation of the teak seeds by these field fungi clearly indicates the possibility of infection by the pathogen during the early developmental phase of the fruits.

## 2.6. UTILITY OF THE RESEARCH RESULTS/FINDINGS

Location and period of seed collection for the species *Acacia nilotica*, *Albizia lebbeck*, *Dalbergia sissoides*, *Neolamarckia cadamba* and *Tectona grandis* have been specified. This will help collection of seeds of these species. For teak, seed stands were already available, but the variation in time of seed collection has been documented for Chinnar for the first time. Seed extraction methods, pre-treatment, light condition for germination, which have been understood, through the project, will be of great use to people engaged in seed handling and plant production.

Seed samples were also supplied to the Chief Technical Advisor, Dehra Dun for conducting various studies. Details of seeds supplied are given in Table 70.

**Table 70. Details regarding seeds despatched to Dr. R. C. Thapliyal, Scientist-SE, Chief Technical Advisor, Forest Tree Seed Laboratory, Silviculture Division, Forest Research Institute, Dehra Dun on 08.06.1999.**

| Sl No. | Species | Seed zone | Sub-zone | Locality | Date of collection | Quantity (g) | Sample No. | Official identity Number |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1 | *Albizia lebbeck* | KL-3 | Palakkad | Chandra nagar | 17/02/98 | 75.00 | PAl-1 | CAl- (1) |
| 2 | ,, | ,, | ,, | Kuzhalmandam | 17/02/98 | 150.00 | PAl-2 | KAl -(1) |
| 3 | ,, | ,, | ,, | ,, | 14/11/97 | 245.80 | PAl-2 | KAl- (1) |
| 4 | ,, | KL-2 | Munnar | Champakkad | 31/08/97 | 50.00 | MAl-1 | CAl- (12) |
| 5 | ,, | ,, | ,, | Olamattom | 04/02/98 | 60.00 | MAl-5 | OAl- (1) |
| 6 | ,, | ,, | ,, | Karimutty | 26/05/98 | 12.00 | MAl-1 | KAl- (2) |
| 7 | *Neolamarckia cadamba* | KL-3 | Palakkad | Dhoni | 14/11/97 | 20.00 | PAC-1 | DAC- (1) |
| 8 | ,, | ,, | ,, | ,, | 09/11/98 | 20.00 | PAC-1 | DAC- Mixed (1) |
| 9 | ,, | ,, | ,, | ,, | 22/10/98 | 30.00 | PAC-1 | DAC- Mixed (2) |
| 10 | ,, | ,, | ,, | ,, | 17/09/98 | 14.00 | PAC-1 | DAC-Mixed (3) |
| 11 | ,, | ,, | ,, | ,, | 17/09/98 | 3.00 | PAC-1 | DAC- Mixed (4) |
| 12 | ,, | ,, | ,, | ,, | 18/09/98 | 2.00 | PAC-1 | DAC-Mixed (5) |
| 13 | ,, | ,, | ,, | ,, | 09/11/98 | 35.00 | PAC-1 | DAC- Mixed (6) |
| 14 | ,, | ,, | ,, | ,, | 09/11/98 | 20.00 | PAC-1 | DAC- Mixed (7) |
| 15 | ,, | ,, | ,, | ,, | 22/10/98 | 150.00 | PAC-1 | DAC- Mixed (8) |
| 16 | ,, | ,, | ,, | Mukkali | 24/09/98 | 2.50 | PAC-1 | MAC- (1) |
| 17 | ,, | KL-2 | Malayattur | Kannimangalam | 19/09/98 | 2.50 | MAC-1 | KAC- (1) |
| 18 | ,, | ,, | ,, | ,, | 06/11/98 | 1.50 | MAC-1 | KAC- (2) |
| 19 | ,, | ,, | ,, | ,, | 07/11/98-10/11/98 | 2.00 | MAC-1 | KAC- (3) |
| 20 | ,, | KL-3 | Nilambur | Nellikkuthu | 07/10/98 | 25.00 | NAC-1 | NAC- (1) |
| 21 | ,, | ,, | ,, | ,, | 07/10/98 | 1.50 | NAC-1 | NAC- (2) |
| 22 | ,, | ,, | ,, | ,, | 17/10/98 | 90.00 | NAC-1 | NAC- (3) |
| 23 | ,, | ,, | ,, | ,, | 13/11/98 | 125.00 | NAC-1 | NAC- (4) |
| 24 | ,, | ,, | wayanad | Ondayangadi | 09/10/98 | 2.50 | OAC-1 | OAC- (1) |
| 25 | *Tectona grandis* | KL-3 | Palakkad | Pothundi | 18/02/98 | 1250.00 | PTg-1 | PTg-Mixed |
| 26 | ,, | KL-3 | Nilambur | Nellikkuthu | 26/03/98 | 1150.00 | NTg-1 | NTg-Mixed |
| 27 | ,, | KL-1 | Konni | Aruvapalam | 06/03/98 | 1500.00 | KTg-1 | ATg-Mixed |
| 28 | ,, | KL-2 | Munnar | Karimutty | 26/05/98 | 300.00 | MTg-1 | KTg-Mixed |
| 29 | ,, | KL-2 | Munnar | Champakkad | 26/05/98 | 300.00 | MTg-2 | CTg-Mixed |
| 30 | ,, | KL-2 | Munnar | Churulipetty | 26/05/98 | 300.00 | MTg-3 | CYTg-Mixed |
| 31 | ,, | KL-2 | Munnar | Alampetty | 26/05/98 | 200.00 | MTg-4 | ATg-Mixed |
| Total | | | | | | 6139.30 | | |

## Explanations:

Column: 3: Zone: As suggested by ICFRE
Column: 4: Sub-zone: As suggested by ICFRE
Column: 5: Name of the area where seed tree is located
Column: 8: Sample No. : First letter corresponds to Sub-zone number (eg. P – Palakkad)
Second and third letters corresponds to species name (eg. Al- *Albizia lebbeck*)
Serial number corresponds to locality number in the Sub-zone
Column 9: Official identity No. : First letter corresponds to locality (eg. C- Chandranagar)
Second and third letters corresponds to species name (eg. Al- *Albizia lebbeck*)
Number corresponds to tree number 'Mixed' refers to seed collection from the ground below the sample tree but includes seedsof other neighbouring trees as well. This was done due to the non-availability of sufficient seeds from the marked trees as well as practical difficulties in collecting from individual trees.

## 3. PART –C

### 3. 1. DETAILS OF THE PUBLICATION MADE OF THE BASIS OF THE POJECT WORKS

Nil

### 3.2. PATENTS IF ANY (APPLIED OR ACCRUED)

Nil

### 3.3. END USERS TO WHOM THE REEARCH FINDINGS NEED TO BE CIRCULATED

(i) Forest departments
(ii) Forest colleges
(iii) Govt. organizations and NGOs involved in tree planting.

### 3.4. WHAT ASPECT OF THE RESEARCH PROBLEM NEED FURTHER INVETIGATION INCASE A NEW PROPAOSAL IS TO BE SANCTIONED IN THE SAME SUBJECT / ASPECT

(i) Storage studies with the seeds of *Dalbergia sissoides* and *Neolamarckia cadamba.*

(ii) Effect of light intensity on germination of seeds *Acacia nilotica*, *Albizia lebbeck*, *Dalbergia sissoides* and *Neolamarckia cadamba.* The physiology of seed germination may be studied in detail.

(iii) Clonal propagation in *Acacia nilotica*, *Albizia lebbeck*, *Dalbergia sissoides* and *Neolamarckia cadamba.*

# 4. PART –D (ANNEXURES)

## 4.1. CONSOLIDATED UTILIZATION CERTIFICATE

TO BE SENT IN DUPLICATION TO THE I.C.F.R.E. FOR THE PERIOD 9 JUNE 1997 TO 25th JANUARY 2002

| | | | |
|---|---|---|---|
| 1. | Title of the project/scheme | : | Development of technology for collection, processing and testing seeds of five important tree species of Kerala |
| 2. | Name of the organization | : | Kerala Forest Research Institute<br>Peechi - 680 653, Thrissur, Kerala |
| 3. | Principal Investigator | : | Mr. K.C. Chacko |
| 4. | I.C.F.R.E. sources letter No. & date of sanctioning the project | : | 38-6/97-ICFRE(R) dated 31 March 1997<br>The commencement date of the project is 9 June 1997 vide letter 38-6/97-ICFRE(R) dated 21 January 1998 |
| 5. | Amount received from ICFRE (Please give No. & dates of sanctions showing the account paid) | : | Rs. 6,83,860/-<br>38-6/97-ICFRE(R) dated 09/06/1997<br>Rs. 1,30,838/-<br>38-6/97-ICFRE(R) dated 07/03/2001<br>*20,000 was sanctioned vide letter No. 38-6/97-ICFRE(R) dated 29/10/1998 as salary arrear for JRFs |
| 6. | Total amount that was available for expenditure (excluding commitments) incurred during the financial year (9th half year) | : | Rs. (-) 2,62,306.25 |
| 7. | Actual expenditure (excluding commitments) incurred upto 25.01.2002. | : | Rs. 10,7,004.25 |
| 8. | Unspent balance (carried over) | : | Rs. (-) 2,62,306.25 |
| 9. | Balance amount available at the end of the 9th half year | : | Rs. (-) 2,62,306.25 |
| 10. | Amount allowed to be carried forward to the next financial year vide their No. | : | Nil |

*Rs. 20, 000/- was sanctioned as salary arrears for Research Fellows

Certified that expenditure of Rs. 10,77,004.25/- (Ten lakhs seventy seven thousand four rupees and twenty five paise only) mentioned against Col. 7 was actually incurred on the project scheme for the purpose for which it was sanctioned.

Date: 25th January 2002

Signature of principal Investigator

Signature of Registrar Accounts Officer

Signature of Head of the Organization

Dr. J. K. SHARMA
DIRECTOR
KERALA FOREST RESEARCH INSTITUTE
PEECHI – 680 653, THRISSUR
KERALA INDIA

ACCEPTED AND COUNTERSIGENED
Kerala Forest Research Institute
PEECHI - 680653

kfri 279/97

## 4.2 CONSOLIDATED STATEMENT OF RECEIPTS & EXPENDITURE

STATEMENT SHOWING CONSOLIDATED RECEIPT & EXPENDITURE (RUPEES)
FOR THE PERIOD FROM 9TH JUNE 1997 TO 25 JANUARY 2002

| Head of account | Sanctioned grant for the project | Total amount received from ICFRE | Total expenditure | Balance available | Grant due for release upto JUNE 2001 | Deviation from sanctioned project budget | |
|---|---|---|---|---|---|---|---|
| | | | | | | Over spent | Under Spent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Salaries and wages | 2,55,600 | 42,600 | 3,50,850.00 | (-) 3,08,250 | 2,13,000 | 95,250 | Nil |
| Travelling Expenses | 50,000 | 20,000 | 1,05,636.85 | (-) 85636.85 | 30,000 | 55,636.85 | Nil |
| Equipment (non-recurring) | 5,05,000 | 5,05,000 | 3,70,303.00 | 1,34,697.00 | Nil | Nil | 1,34,697 |
| Contingencies office expenses, etc (recurring) | 3,00,000 | 1,00,000 | 1,63,715.60 | (-) 63,715.60 | 2,00,000 | Nil | 1,36,284.40 |
| 10% institutional Administrative charges (except equipment) | 60,560 | 16,260 | 71,498.80 | (-) 55,238.80 | 44,300 | Nil | 10,938.80 |
| Total | 11,71,160 | 6,83,860<br>(+)1,30,838=<br>8,14,698 | 10,62,004.25<br>(+) * 15,000.00=<br>10,77,004.25 | (-) 3,78,144.25<br>(-) 1,30,838<br>(+) * 15,000=<br>(-) 2,62306.25 | 4,87,300<br>(-) 1,30,838=<br>3,56,462 | 1,50,886.85 | 2,81,920.20 |

* Rs. 15,000/- for report preparation

Certified that the grant received has been utilized as per rules and regulations of this Institute for the purpose for which it was sanctioned

Principal Investigator/ Head of Department

Senior Finance & Accounts Officer

REGISTRAR
Kerala Forest Research Institute
PEECHI-680653

kfri 279/97

## 4.3. LIST OF EQUIPMENTS PROCURED

| Sl No. | Item | Number |
|---|---|---|
| 1 | Oven | 1 |
| 2 | Deep freezer | 1 |
| 3 | Incubation cum growth chamber | 1 |
| 4 | Seed germinator | 3 |

Kerala Forest Research Institute

# REGISTER OF FIXED ASSETS

Stock No.....

Serial No .....

Description of Fixed Assets (details of attachments and accessories also to be furnished) HOT AIR OVEN – ONE (Inside Stainless Steel with Air Circulating Fan and Indicator Puma-Controller 600 x 600 x 900 mm)

Maker's Name/Number

Supplier "SCIENTIFIC" ENTERPRISES, TRIPUNITHURA- 682 301.

Purpose –do–

Date of purchase 24.5.99.

Rate of Depreciation.....

Division to which distributed SILVICULTURE

Shri K.C. Cherko.

Serial No. 120

| Cost | Voucher No. & Date | Rs. | Ps. | Initial | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Purchase price | IN.NO. 6715 dt 24/5/99 | 22,400 | 00 | SL | 1999. | (Pl. See the original bill for receipt). | | | | | | | | |
| Installation | | | | | | | | | | | | | | |
| Modifications | | | | | | | | | | | | | | |

## MAINTENANCE

| Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initial | Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initi |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

# REGISTER OF FIXED ASSETS

Stock No.....

Serial No.....

"AB LINE" SEED GERMINATOR.

10°C to 60°C 40% to 95% - ONE
Humidity range.

CFL RECENT Lamps - ONE

ELEC. TIMER - ONE.

21. Slopped Thermometer - ONE

Rate of Depreciation.....

Serial No. 149

Purr. 279/97

Division to which distributed SILVICULTURE.

22.12.99. by SCIENTIFIC SERVICES & Shri K.C. Chacko.
Agencies, Tripamchura.

| Voucher No. & Date | Rs. | Ps. | Initial | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inv. No. | | | | | | | | | | | | | |
| 5/12/99 | | | | | | | | | | | | | |
| 2000 Opp. | | | | | | | | | | | | | |
| 22/12/99. | 64,182 | 00 | + | | | | | | | | | | |
| | 3209 | 00 | | 5% Discount. | | | | | | | | | |
| | = 60973 | 00 | | | | | | | | | | | |

| | Vr. No. & Date | Cost Rs. | Cost Ps. | Initial | Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initial |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

# REGISTER OF FIXED ASSETS

on of Fixed Assets
of attachments and
s also to be furnished)

LAB LINE SEED GERMINATOR 10°C to 60°C
CAPACITY 285 Ltr. WITH 8 TRAYS - ONE
CHAMBER ILLUMINATION - ONE
CYCLIC TIMER 0-24 HRS - ONE
'L' SHAPED THERMOMETER - ONE.
" SCIENTIFIC SERVICES & AGENCIES
TRIPUNITHURA.
-do-
PROJ 279/96.
03-2-2001

Stock No.....

Serial No.....

Name, Number

Rate of
Depreciation.....

Purchase

Division to which
distributed
KAU 279/96
SIC - SILVI.

Serial
No. 221

| Cost | Voucher No. & Date | Rs. | Ps. | Initial | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| price | Inv. 69/ | | | | | | | | | | | | |
| on | 2000-01 | | | | | | | | | | | | |
| | dt: | | | | | Pl. See receipt in Original Inv. | | | | | | | |
| | 31/2/01 | 60,973 | 00. | SL | 2001 | C/R receipt of SIC (SILVI). | | | | | | | |
| ions | | (60,550-00 + | | | | | | | | | | | |
| | | ~~741 7½ +~~ | | | | | | | | | | | |
| | | 2660 + | | | | | | | | | | | |
| | | 250 | | | | | | | | | | | |
| | Less 5% discounts) | | | | | | | | | | | | |

**TENANCE**

| Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initial | Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initi |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

# Kerala Forest Research Institute

## REGISTER OF FIXED ASSETS

Stock No.....

Serial No .....

Description of Fixed Assets (details of attachments and accessories also to be furnished) 'LABLINE' FOREST DEEP FREEZER Model FUDE-281
285 Ltr - ONE.
DIGITAL Temperature Indicator ONE.

Rate of Depreciation.....

Maker's Name/Number SCIENTIFIC SERVICES & AGENCIES, TRIPUNITHURA.

Supplier -do-

Purpose

Date of purchase 23/3/01.

Serial No.

Division to which distributed SIC (SILVI)

| Cost | Voucher No. & Date | Rs. | Ps. | Initial | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. | Year | Depreciation Rs. | Depreciation Ps. | Book Rs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Purchase price | Inv. No. | | | | | | | | | | | | |
| Installation | 674/2000-01 3/4/01 | 59610 | 00 | SL | 2001 | | | | | | | | |
| | | (55810 | 00 | | | | | | | | | | |
| Modifications | | + 3800 | 00) | | | | | | | | | | |

**MAINTENANCE**

| Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. | Initial | Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

# Kerala Forest Research Institute

## REGISTER OF FIXED ASSETS

Description of Fixed Assets (details of attachments and accessories also to be furnished): LABLING SEED GERMINATOR 10'C x 60'C.
CHAMBER INCUBATION 870 x 570 x 755 mm. 285 Ltr.
8 TROYS L' SHAPED MONETER. ALL - 1 each.

Stock No.....
Serial No .....

Maker's Name/Number
Supplier: SCIENTFIC SERVICES & AGENCIES. TRIPUNITHURA.
Purpose: -do-
Date of purchase: Proposed 279/98. 03-2-2001

Rate of Depreciation .....

Division to which distributed: SIC - (Silvi).

| Cost | Voucher No. & Date | Rs. | Ps. | Initial | Year | Depreciation Rs. | Depreciation Ps. | Book Value Rs. | Book Value Ps. | Year | Depreciation Rs. | Depreciation Ps. | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Purchase price | Proposed. | | | | | | | | | | | | |
| Installation | 655/2000 | 60580 | 00 | + | | | | | | | | | |
| | 01 dd. | 712 | 00 | | | | | | | | | | |
| | 3-2.01 | 2660 | 00 | | | | | | | | | | |
| | | 250 | 00 | | | | | | | | | | |
| Modifications | = | 64182 | 00 | | | | | | | | | | |
| Less | 5% dis | | | | | | | | | | | | |
| | Cent. | = 60973 | 00 | E | 200 | | | | | | | | |

### MAINTENANCE

| Year | Details | Vr. No. & Date | Cost Rs- | Cost Ps. | Initial | Year | Details | Vr. No. & Date | Cost Rs. | Cost Ps |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |