STANDARDISATION OF ROOTING MEDIA FOR SELECTED TREE CROP SEEDLINGS WITH SPECIAL REFERENCE TO PLANT NUTRIENTS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled "**Standardisation of rooting media for selected tree crop seedlings with special reference to plant nutrients**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship, associateship or any other similar title of any other university or society.

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Dedicated to the memories of my brother

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Strange and great are the ways of THE POWER ..... O' HOLY MOTHER, you are everything for me.

SUDHEESAN, V.P.

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Introduction

INTRODUCTION

Tropical forests are disappearing at an alarming rate. The global rates of deforestation is estimated to be of the order of about 17 million hectares every year (F.A.O., 1992) and it is feared that some of the valuable tree species and many useful timber, fuel and fodder tree species may become extinct in the course of time. In the Indian context also, the increasing population, expanding urbanization, rapid industrialisation and accelerated pace of development activities have resulted in significant shrinkage of our forest resource base. The Indian farmers are required not only to increase food output per unit of land area, but also to produce fodder and fuel wood on the farm itself. It is estimated that by the turn of this century, we may require about 250 million tonnes of food grains, 2085 million tonnes of green and dry fodder, 350 million tonnes of fuel wood and about 63 million m^3 of timber (NRCAF, 1991). The present production is incapable of meeting even 50 per cent of this projected demand. The large scale afforestation and reforestation programmes being conducted are intended to make up for this loss. Production of large number of quality seedlings to meet the requirement of the target is an urgent need during these days. Healthy and vigorous seedling will surely manifest in the final outcome of the plant.

Information about the influence of media on growth and vigour is absolutely essential for large scale production of healthy seedlings in the nursery. A cheap and a highly successful medium will enable the farmers and foresters to produce high quality seedlings of forest tree species for extensive planting under agro/social forestry programmes. This will be a very valuable information for general afforestation. But not much attention has been given to this in tropics except in horticultural and ornamental plants.

The present study was conducted to find out the effect of easily available and cheap rooting media on the growth and vigour of seedlings of selected tree species grown in Kerala.

The concentration of nutrients in the seedlings will be an expression of the type of the media in which the plants are grown which in turn will indirectly affect the vigour and quality of the seedlings. In order to standardise the rooting media, the knowledge on the concentration of nutrient elements in the soil and plant during different periods of the seedling growth is essential.

Review of Literature

REVIEW OF LITERATURE

The effects of different media on the growth performance of tree seedlings have been studied by various workers.

1 Effect of rooting media on seed germination and seedling vigour

Simpson (1985) suggested that addition of vermiculite may result changes in the nutrient content by producing high quality seedlings of *Pseudotsuga menziesii, Pinus contorta, Picea glauca, Tsuga heterophylla* and *Abies lasiocarpa* when grown in sewage sludges or wooden waste/sewage sludge composts.

Large sized, heathy seedlines were obtained when the seeds of Pedunculate Oak (*Quercus robur*) were sown in beds of mixed peat, soil and fertilizer compared to seedlings raised in polythene bags (Buresti, 1986). A 1:2 combination of perlite and garden soil was found to be a good potting medium for seedlings of *Samanea saman* while pure perlite was found to be good for *Leucaena leucocephala* seedlings (Rimando, 1987). Beniwal and Dhawan (1991) observed maximum germination of seeds of *Anthocephalus chinensis* when sown in pure soil medium. But growth was better in treatment containing FYM.

Good results were obtained when scots pine seedlings were grown using powdered green needles of scots and australian pinc and mixed with one part of sand and one of perlite (Papp, 1981).

Barrett (1983) proved that filter cake was significantly poorer medium than peat moss or pine saw dust producing smaller plants with *Pinus patula, Pinus ellioti* and *Pinus taeda* seedlings.

Uniform sized seedlings of casuarina and sandal and stumps of teak in a soil/sand mix in polybags, were treated with two doses of NPK fertilizer. The treatments increased growth and nutrient contents in casuarina and teak, but induced toxicity symptoms and subsequent mortality in sandal (Rangaswami *et al.*, 1990).

For nang seeds to germinate, best media were reported to be sawdust and a mixture of sand and sawdust and for red lauan were sand or a mixture of sand and garden soil (Garcia *et al.*, 1983).

According to Bhardwaj *et al.* (1986) an equal mixture of soil, sand and FYM was found to be ideal for growth of *pinus roxburghii* Sargent seedlings.

Cizkoa (1987) revealed that acidic media affecting severely the vigour of *Pinus abies* than that of *Pinus mugo* seedlings.

Presence of cow manure in the growth medium was found to be related with high mortality, retarded growth and needle yellowing in *Pinus caribaea* seedlings (Msanga and Shehaghilo, 1980).

Studies by McConnel (1987) indicated that *Eriobotrya japonica* seedlings were growing better in a medium containing peat, vermiculite, sand bark ash and pine bark in equal proportion.

Pure soil was found to promote better growth of *Pinus merkusii* seedlings (Suhaendi, 1986).

The growth of larch seedlings was affected positively by peat/baryn yard manure/forest surface soil (1:1:2) combination (Lo *et al.*, 1981).

A study was made to find out the suitability of three rooting media (forest soil/sand, 5:1, forest soil/cattle manure, 1:1 and sand/cattle manure, 1:1) for raising seedlings of *Eucalyptus camaldulensis, E. tereticornis* and *Leucaena leucocephale* in the nursery. The media containing cattle manure were found better for all three species than the one without it. *E. camaldulensis* performed equally well in sand/cattle manure and forest soil/cattle manure, while the growth of *E. tereticornis* was better in sand/cattle manure. Eucalyptus required a larger container than Leucaena leucocephala in order to maintain healthy growth in the nursery, especially when cattle manure was used in the growing medium (Anon, 1989).

Rimando's (1981) study indicated the superiority of medium containing humus and sand in 2:1 ratio for the growth of *Casuarina equisetifolia* seedlings and medium containing humus and decomposed coir dust in 1:2 ratio for *Pithecollobium dulce* and *Geiricedia sepium* seedlings.

Daryono (1982) observed that *Eucalyptus urophylla* grew well in nursery containers filled with pure latosol and *Maesopsis eminii* in 1:3 soil and sand mixture. The height growth was more in *Eucalyptus urophylla* compared to other species.

Skolmen and Roo (1986) conducted a detailed study to evaluate the effect of various types of media on the growth of casuarina and eucalyptus seedlings. Potting mixtures containing pieces of paper resulted in complete failure of growth of seedlings. Similarly mixtures with subabul leaves resulted in poor seedling survival and growth. Mixtures of sand, soil and grass clippings were found most ideal for the growth of *Eucalyptus saligna* and *Casuarina equisetifolia* seedlings.

Aguiar *et al.* (1988) recorded maximum height, fresh weight and root collar diameter in *Eucalyptus citriodora* seedlings when grown in superfine and micron vermiculite.

Donald and Visser (1989) while studying the possibility of vermicompost as a possible growth medium for the production of commercial forest nursery stock found that survival and growth of *Acacia mearnsii* were significantly reduced by vermi compost. *Eucalyptus grandis* grew well in pure pine bark and 1:1 mixture of pure pine bark and pure vermi compost. Survival of *Pinus patula* was not affected by vermi compost but growth was reduced. All the three species responded to the addition of inorganic fertilizers for satisfactory growth regardless of the compost mixture used.

Seedlings of *Eucalyptus urophylla* growing in nursery beds (at Bogor, Indonesia) in three media (a) clay/fine sand, 2:1; (b) clay/ aged saw dust, 2:1 and (c) clay/fine sand/aged saw dust, 2:1:1 were compared for height and diameter measurements. Overall, best height growth was obtained with media (b) followed by (c) and (a) (Anon, 1989).

Maithani *et al.* (1988) studied the effect of different soil media and size of containers on the germination and growth of seedlings. Growth of *Acacia nilotica* was found to be slightly higher in sand, soil and FYM mixtures in 1:2:1, 1:3:1 and 1:1:1 proportions than forest soil alone. However, media did not influence the growth of *Albizia procera* seedlings. In the case of *Dalbergia latifolia*, mixtures of sand, soil and FYM (1:2:1 and 1:1:1) were found to be good (Kumar *et al.*, 1991).

Cuttings of black spruce (*Picea mariana*) appeared unhealthy when grown in media including field soil but were healthy and growing vigorously in media containing only peat and vermiculite (Phillion *et al.*, 1982).

Pawuk (1981) observed that long leaf and short leaf pines have grown equally well in a medium consisting of peat and vermiculite in 1:1 ratio and having low pH. The shredded pine cone media was proved better compared to pine bark media. Growth was increased when soil or vermiculite was added to cone or bark chips. Commercial bark or vermiculite media having high pH, produced smallest seedlings.

Igaunis (1984) conducted a detailed study to findout the preferred medium for 93 different species. It was found that twelve species mainly shrubs grew better on mineral soil compared to peat.

Growth of sandal seedlings at six month old was measured after raising from seed in the nursery of the Forest Research and Development Centre at Bogor in polythene pots, with three different host plants and in five different growth media. No effect of host plant on growth was demonstrated but type of growth media had a highly significant effect on height and diameter growth, root development and shoot/root ratio. Seedlings grew best in ash of burned rice chaff, and least in a soil and saw dust mixture (1:3) (Widiarti, 1989).

Ferda and Havelka (1982) studied the utilization of crushed waste bark for the preparation of growing media. Pure bark was not found to be satisfactory. Similarly slightly decomposed peat which was generally preferred for growing media was also less satisfactory compared to moderately decomposed peat in mixtures with bark.

Bahuguna *et al.* (1987) found that among the soil media, seeds germinated earlier in soil sand (1:1) without FYM. Soil sand (1:1) and 2:1 gave better germination than soil sand FYM in 1:1:1 or 2:1:1. Results showed that FYM is essential for better growth of the seedling after completion of germination. The effect of FYM is further indicated in the diameter growth. Far better diameter growth was observed in treatments with FYM than other treatments.

Daryono (1988) recorded maximum height growth of *Acacia mangium* seedlings on inceptisol and vertisol.

Casarin *et al.* (1989) found that bagasse, a residue of the sugarcane industry reduced the height, diameter and dry weight of *Eucalyptus citriodora* seedlings. While studying the growth performance of *Tectona grandis* seedlings in fifteen different media made by mixing black natural soil, sand and sawdust in different proportions, Yadav *et al.* (1982) reported that growth was better in pure black soil than any other medium.

Misra and Jaiswal (1993) studied the effect of four potting mixtures (loam soil; loam soil + FYM (1:1), loam soil + sand + FYM (1:1:1) and (2:1:1) on survival and growth of one month old seedlings of *Grevillea robusta*. Best survival was reported in soil/sand/FYM at 1:1:1 followed closely by loam soil. Best growth was also in soil/sand/FYM at 2:1:1.

Seeds of *Acacia caven* were sown in nursery beds of six growing media (various combinations of sand, soil, compost and FYM). Observations were made on germination percentage, plant percentage and seedling height and collar diameter at 70, 100 and 115 days old. Significant differences were found between treatments. Best germination was obtained in the 1:1 soil/sand mixture and best growth in 2:1:1 soil/sand/FYM. Sowing in the first medium and transplanting to the second medium is therefore advised (Bahuguna and Pyarelal, 1993a).

Dhar *et al.* (1992) in their studies on the influence of growing media on the growth and drymatter accumulation of *Leucaena leucocephala* observed that FYM was the best medium for raising healthy and vigorous seedlings. Other media tested included various combinations of sand, soil and FYM $\pm$ *Rhizobium* or *Azotobactor* inoculation.

Seeds of *Acacia auriculiformis* were sown in four media (soil/sand/FYM at 2:1:1 and 1:1:1 and soil/sand at 2:1 and 1:1) and based on the observations, Bahuguna and Pyarelal (1993b) concluded that addition of FYM is only needed in later, to stimulate the seedling growth.

In a study to find out the influence of different soil mixtures on nursery growth of some arid zone tree species showed that nursery stock raised on sandy soil is poor, resulting in high mortality on planting out. A nursery experiment was conducted at the Arid Forest Research Institute, Jodhpur, in 1989, in which sand was mixed with various amounts of tank silt (Pond sediment, at 0, 5, 10 and 20%), FYM (0, 2, 4 and 6%), N (0, 10, 20 and 40 ppm as urea) and P (0, 15 and 30 ppm P_2O_5 as single super phosphate), and the mixtures tested as growing media for three species important in Rajasthan (*Dalbergia sissoo, Prosopis cineraria* and *Albizia lebbeck*). Seedling height was recorded after 120 days. All species responded positively to the inclusion of tank silt and FYM in the growing media, but only *A. lebbeck* responded to N, and no species responded to P. The best mixtures for each species were: *D. sissoo*, 10 per cent tank silt + 2 per cent FYM; *A. lebbek*, 10 per cent tank silt + 4 per cent FYM + 40 ppm N and *P. cineraria*, 10 per cent tank silt alone. Use of tank silt also improved the aggregation properties of the media (Gupta, 1992).

The possibility was investigated that the use of saw dust in the germination beds of *Acacia mangium* at the Sabah Forest Development Authority nursery at Bongkol had caused the poor germination found in 1986. Seeds were germinated in three media: soil/sand (2:1), old (mixed species) sawdust, and fresh (mixed species) sawdust. Control seeds were germinated in petridishes in a germination cabinet. Germination reached 80 per cent in the control and in the soil/sand and old sawdust media but germination was poor in fresh sawdust (Anon, 1989).

2 Effect of Media on shoot and root growth

It was noticed by Singh and Sharma (1983) that addition of humus (25, 50, 75 and 100%) to nursery soil improved the growth of spruce and silver fir. It reduced the root:shoot ratio in spruce but not in fir. Addition of humus significantly increased the collar diameter of the seedlings. Increase in growth is increased with humus content.

Studies were conducted on the effect of different substrates and containers on the growth of *Picea pungens* seedlings. Polythene bags filled with a mixture of compost, peat, pine bark and loamy sand were found to be ideal (Mateja and Gorzelak, 1983).

Xie and He (1985) reported that river sand containing nutrients as the best basic medium for *Larix olgensis, Larix gmelinii, Pinus sylvestris, Pinus koraiensis* and spruce seedlings. This media was stated to have good physical proportion.

Growth and root vigour of Norway spruce seedlings were reduced when grown in a sublayer of sand. But with a sublayer of sand, seedlings performed best in peat and worst in a mixture of peat and mineral wool (Langerud and Sandvik, 1987).

Ward *et al.* (1981) studied the effects of containers and media on the growth of sugar maple seedings. Seedlings grown in green house medium (1/3 peat, 1/3 perlite and 1/3 loamy sand) exhibited highest root collar diameter, root and shoot weight and height.

Zhou (1988) carried out trials by raising willow saplings in a subsiding area mined for coal and newly filled with different media and covered with a layer of sandy soils. The best medium was burgy covered with 10 cm of sandy loam. All the three cultivars of salix had a survival rate of cent per cent and good growth.

The growth of *Didymopanax morototoni* seedlings in different soil mixture was studied by Marques and Yared (1984) and reported that a mixture of yellow latozols, sand and compost in 3:1:1 ratio gave the best results. Treatment with 1:2:1 NPK fertilizer mixture at the rate of three gm/bag increased weight and root collar diameter growth but reduced the survival.

It was pointed out by Worrall (1982) that plants grown in light medium required fewer waterings than those grown in heavy mixtures when planted out in the field.

Based on the study conducted by Girouard (1983) in balsam fir, the ideal rooting and planting media were sphagnum, sphagnum or peat moss with vermiculite in 3:1 or 2:1 ratio and peat moss with sand in 2:1 ratio.

The seedlings of *Erythrina falcata* grown with cowdung when harvested on 45th, 75th and 150th day recorded maximum dry weight and total nitrogen content compared to those grown without cowdung (Freitas *et al.*, 1980).

Tripathi and Bajpai (1984) conducted experiments to find out the influence of various potting media on the growth of *Anogeissus pendula* seedlings. They found that overall growth performance in terms of number of leaves, shoot and root length and also fresh and dry weight of shoot was more in sand followed by red soil. The saw dust was most inferior with regard to above parameters.

Chang *et al.* (1987) used mushroom compost and paper mill sludge as soil amendments for containerized nursery crops. The secondary sludge alone was found to promote the growth of *Spiraeax bumalda*, but the foliage colour was very dark blue green. There was little or no difference in foliar N and P between the different sludge treatments.

Langeund and Sandvik (1988) studied the development of containerized *Picea abies* seedlings grown with heavy matering on various peat, perlite and mineral wool mixtures. Seedlings grown in media containing mineral wool recorded less mortality and were having larger and more living root apices than seedlings grown in media lacking mineral wool. The media also resulted qualitative differences in shoots and roots including the number of secondaries and living root apices.

A study by Abdulbari and Prasad (1987) revealed that site and soil factors play a major role in the suitability of tropical pine species and their provenances. Soils of sandy loam texture seem to be ideal for raising some provenances, while soils of heavier texture seem to retard the growth after the third year. The provenances grew well under low fertility conditions and a moderately acidic soil environment.

One year old bare root seedlings were potted into No. 10 (large) containers in (1) pine bark (2) 80 per cent pine bark + 20 per cent sand by volume or (3) 60 per cent pine bark + 40 per cent sand. It was found that the growing medium did not influence height during the first season but in the second season, the greater increase was found in medium (3) with the highest sand content (Martin *et al.*, 1988).

Yadav and Goswami (1990) made a study to know the effect of seven media on the rooting behaviour of one node + one leaf cuttings of sam (*Persea bombycina*), one of the primary food plants of the muga silkworm, *Antheraea assama*. Soil + sand + FYM in equal proportions was found to be the most effective medium for better rooting percentage, more number of primary roots, secondary roots, mean length of roots, length of the largest roots, number of newly originated leaves in newly originated shoot and survival percentage.

Cizkova (1981) conducted a study in spruce, pine and larch seedlings and found that the seedling growth and chlorophyll content were significantly increased with high nitrogen content.

Sun (1987) proved that in *Acacia confusa*, lack of chlorophyll b, resulted in a lower ability to absorb light which resulted in reduced photosynthetic capacity and growth.

Rooting medium significantly increased leaf area. Chattopadhyay and Mohanta (1988) found that leaf number was greater in seedlings treated with cow-dung.

3 Nutrient composition and growth of seedlings

Eusebio *et al.* (1984) observed that seedling growth and CEC of the medium mainly depend on the chemical composition of the mixture. A potting mixture of saw dust and soil in equal proportions influenced the growth of *Albizia falcataria* and *Pterocarpus indicus* seedlings significantly compared to saw dust or soil when used alone.

Poole and Conover (1985) studied the growth of *Ficus benjamina* seedlings planted in potting media containing various combinations of Florida sedge peat, builders' sand and shredded portions of *Melaleuca quinquenervia* bark and wood. As the percentage of shredded melaleuca bark and wood decreased, the pH and percentage of non capillary pore space decreased resulting an increase in soluble salts and capillary pore space. An increase in sand increased pH, soluble salts and bulk density but decreased cation exchange capacity and percentage capillary pore space.

Seedlings of *Acacia mangium* were grown in ultisol and also in mixtures of decomposed saw dust, coir dust or peat. Ultisols were having poor aeration, high bulk densities, low water holding capacities and hence were generally unsuitable as nursery potting media. Height and diameter growth were found to be improved in ultisol mixed with saw dust or coir dust and also in pure peat. It was also seen that the growth in pure saw dust or coir dust was significantly inferior compared to other media (Hendromono, 1988).

Mohan *et al.* (1990) studied the response to nutrients by selected social forestry species under varying soil texture. *Albizia lebbek, Peltophorum pterocarpum* and *Eucalyptus tereticornis* were found highly responsive to both soil texture (growing best in clay) and nutrient application. *Albizia amara* grew best in sandy soil. Almost all species tested grew well in clay soil.

Banerjee *et al.* (1986) studied soils from a *Eucalyptus tereticornis* nursery of South Bengal for their morphological characteristic and physico-chemical attributes. Chemical composition of the soils has been influeced to a great extent by drainage condition, differential transport of eroded material, leaching, translocation, redeposition of mobile soil constituents and formation and abundance of mottles. Chemical composition also indicates trends of laterisation of organic matter and breakdown of parent material into free silica and sesquioxides.

The effect of waste material on the growth of seedlings were studied by Skoupy (1980). Good results were obtained when Douglas bir and larch (*Larix decidua*) were grown in a mixture of composted bark and peat taken in equal proportions. An increase in the composted bark and peat in the ratio of 3:1 gave poor results, possibly owing to nutrient deficiency.

In order to study the germination behaviour in different media, Hamzali *et al.* (1995) collected fruits of *Dryobalanops aromatica* from Jalan Kapur and of *Shorea macroptera* from Peninsular Malaysia were dewinged and sown at 2 cm depth with pointed end up in seven growing media - Forest top soil, tinmine sand, forest top soil + sand (at 1:1, 1:2, 2:1, 3:1) and forest top soil + compost + sand (3:2:1). Germination was not significantly different between growing media, but was more for *D. aromatica* (78.5-86.5%) than for *S. macroptera* (62.73%) probably because seeds of the former species were fresher and more uniformly mature.

Kumar *et al.* (1991) found that a combination of soil, sand and FYM in the proportion of 1:1:1 increased the seedling height and dry matter production of *Swietenia macrophylla* and *Dalbergia latifolia* seedlings.

Ramcharan and Gerber (1982) conducted studies on potential use of crushed fruit shells of West Indian Mahogany as a potting media ingredient. The chemical analysis showed that the fruit shells contained reasonably a high concentration of most of the nutrients except N.

While studying the nutritional requirements of forest trees, Hassan and Dey (1979) applied all possible combinations of N, P and K at 0, 250 and 500 mg/plant monthly to six week old seedlings growing in sand culture. Micro nutrients were also supplied. Height and diameter growth and seedling condition were recorded monthly, root and shoot dry weight N and P contents were determined at the end of the experiment. Best growth was obtained with N, P and K at 250 mg/plant monthly at which concentrations of N and P were also highest.

Materials and Methods

MATERIALS AND METHODS

The present investigation to identify the best rooting media for some important tree crop seedlings were carried out in the Instructional Farm, College of Horticulture, Vellanikkara, Thrissur, Kerala during the period from November 1994 to July 1996.

1 Study site

Geographically, the place lies between 13° 32' N latitude and 76° 26' E longitude. Altitude is about 40 m above mean sea level.

1.1 Climate

The area experiences a warm humid climate with a relatively high precipitation. Diurnal variation in temperature is very less. The weather parameters during the experimental period are given in Fig.1.

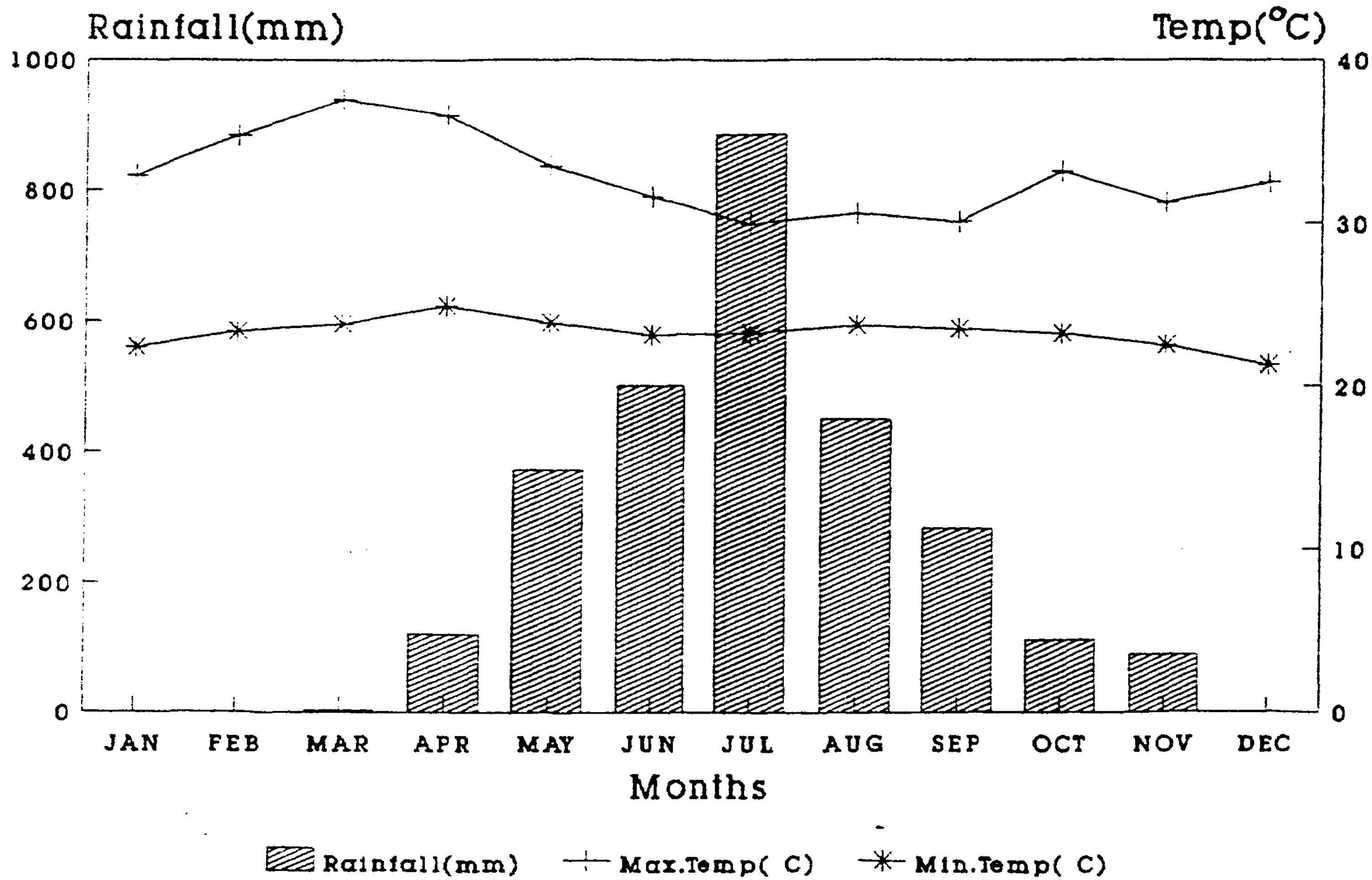
1.2 Soil

The soil of the experimental site is oxisols. The predominant parent material is metamorphic rock of gneiss series. The average soil pH was found to be 5.6. The soils and sub-soils were porous and extremely well drained.

Treatments

The first experiment consisted of the following treatments.

Fig. 1 Weather parameters during the study period (January 95 to December 95)



Rooting Media

1. Soil alone
2. Soil 2/3 + Sand 1/3
3. Soil 1/3 + Sand 1/3 + FYM 1/3
4. Soil 1/3 + Sand 1/3 + Sawdust 1/3
5. Soil 1/3 + Sand 1/3 + Coir fibre waste 1/3
6. Soil 2/3 + FYM 1/3
7. Soil 2/3 + Saw dust 1/3
8. Soil 2/3 + Coir fibre waste 1/3

The depth of the rooting media was 15 cm. The rooting media were applied on volume basis.

Species utilised for the study

1. *Albizia falcataria* (Albizia)
2. *Casuarina equisetifolia* (Casuarina)
3. *Gmelina alborea* (Gmelina)
4. *Tectona grandis* (Teak)
5. *Vateria indica* (Vateria)
6. *Swietenea macrophylla* (Mahogany)
7. *Ailanthus triphysa* (Ailanthus)

Based upon the observations made during the first year, during the second year the rooting media treatments were modified as follows:

Rooting mediaum

Notation

1. T_1 : Soil (1/3) + Sand (1/3) + FYM (1/3)
2. T_2 : Soil (1/2) + Sand (1/3) + FYM (1/6)
3. T_3 : Soil (1/2) + Sand (1/3) + Neem cake (1/6)
4. T_4 : Soil (1/2) + Sand (1/2)

The rooting media were applied on volume basis. The depth of the rooting media was 15 cm.

The species used for the study

Notation

1. S_1 : *Albizia lebeck* (Albizia)
2. S_2 : *Ceiba pentandra* (Ceiba)
3. S_3 : *Dalbergia latifolia* (Dalbergia)
4. S_4 : *Hopea parviflora* (Hopea)
5. S_5 : *Santalum album* (Sandal)
6. S_6 : *Tectona grandis* (Teak)

Experimental design

The experiment was laid out in split plot design with rooting media as the main plots and species as the sub plots.

Number of replication - 3

Plots size - 1.5 m x 1.2 m

Materials

Rooting media

River sand and FYM were obtained from local sources. Commercial grade neem cake was obtained from local market. Saw dust of rubber wood was collected from a saw mill located at Ollur. Coir dust was obtained from unretted coconut husk after extraction of the fibre. It was obtained from Pollachi.

Preparation of nursery bed

Beds of 45 cm height were raised. The beds were having a width of 1.2 m and of sufficient length in such a way that each species occupies an area of 1.5 m x 1.2 m. The width of furrow between two beds was 70 cm. The rooting media like sand, soil, FYM and neem cake etc. were added in such a manner that each of them occupied a depth of 2.5 cm to 7.5 cm in the land ie., they were added by volume. The rooting media were thoroughly mixed and incorporated into the land.

Seed sowing

Necessary pretreatments were given to the seeds in order to hasten germination. In the case of albizia and ceiba, seeds were soaked in water heated previously to 80°C and then allowed to cool for 24 hours before sowing. Seeds of teak were alternatively wetted and dried for 2 days before sowing. Hopea seeds were sown immediately after collection and without any pretreatment. Seeds of dalbergia and sandal were soaked over night in water before sowing.

Observations recorded

Biometric as well as physiological observations were taken at periodic intervals.

1. Growth parameters

Destructive sampling at the rate of nine plants per treatment (three plants per replication) was done at 90, 180 and 270 days after sowing. After measuring height, rooting depth, collar diameter and number of leaves, the leaves, stem and roots were separated and the dry weight of each recorded separately.

The following observations were recorded.

Plant height

Plant height was measured from the collar to the tip of the growing point using a metre scale.

Leaf production of seedings

The number of leaves for each seedlings were counted.

Collar diameter

The collar diameter was measured with the help of a vernier callipers and expressed in mm.

Leaf area

The leaf area of individual plants were measured with an Area meter (Model L1-3100, LI-Cor, Nebraska, USA) and was expressed in cm^2.

Rooting depth

Root depth was measured from the collar to the tip of the longest roots and the mean was expressed in cm.

Population count

The number of plants in each replication of different treatments were counted.

Biomass observations

After biometric observations, stem, leaves and roots were separated and their dry weight recorded separately after drying to a constant weight in an oven maintained at 60°C-80°C.

Stem weight

Average dry weight (g) of the stem, excluding the leaves from the shoot for seedlings were calculated.

Leaf weight

The dry weight of leaves was recorded and the average leaf dry weight per seedling was expressed in grams.

Root weight

The average root dry weight (g) per seedlings was estimated.

Root : shoot ratio

Root : shoot ratio was calculated by dividing the average of the root weight by shoot weight of each plant.

2 Physiological parameters

2.1 Relative Water Content

Relative Water Content (RWC) of the leaf was worked out using the following formula suggested by Barrs and Weatherley (1962). Physiologically mature leaf was fixed by visual observation. It was second to third leaf in the case of *Tectona grandis* and third to fourth leaf in rest of the species. Leaf punches were taken from physiologically mature leaves by using a steel puncher with diameter of 1.5 cm. Three samples were taken from each plant for estimation.

$$RWC\ (\%) = \frac{\text{Fresh weight - Dry weight}}{\text{Turgid weight - Dry weight}} \times 100$$

2.2 Chlorophyll content

Chlorophyll content of the leaf was estimated following the method of Starner and Hardley (1967). Samples were collected from the selected plants, cut into pieces and mixed well, 0.1 g of the sample was weighed into a mortar and ground with a pestle to extract the chlorophyll using 80 per cent acetone. The extract was filtered using Whatman No.1 filter paper and made up to 25 ml using 80 per cent acetone. The absorbance were read at 663 nm and 645 nm wave length in a spectrophotometer. The chlorophyll 'a', chlorophyll 'b' and total chlorophyll of each samples were calculated using the following formulae.

Chlorophyll 'a' (mg g^{-1} of tissue)

$$= 12.7 \text{ (OD at 663 nm)} - 2.69 \text{ (OD at 645 nm)} \times \frac{V}{1000 \times W}$$

Chlorophyll 'b' (mg g^{-1} of tissue)

$$= 22.9 \text{ (OD at 645 nm)} - 4.68 \text{ (OD at 663 nm)} \times \frac{V}{1000 \times W}$$

Total chlorophyll (mg g^{-1} of tissue)

$$= 20.2 \text{ (OD at 645 nm)} + 8.02 \text{ (OD at 663 nm)} \times \frac{V}{1000 \times W}$$

OD = Optical density

V = Final valume of 80% acetone extract

W = Fresh weight of tissue in grams

Soil analysis

Representative soil samples were taken at depth of 15 cm from the soil surface. The soil collected were air dried, grounded and sieved through a 2 mm sieve. These samples were analysed for pH, EC, organic carbon, total and available nitrogen, phosphorus and potassium as per standard procedures.

3 Chemical properties

Organic carbon content of the samples were determined as per Walkley and Black method (Jackson, 1958).

The pH of the soil (1:2.5 soil water ratio) was determined using a pH meter (Jackson, 1958) and electrical conductivity (1:2.5 soil water ratio) was determined by conductivity bridge (Jackson, 1958).

Total N was estimated using microkjeldahal digestion - distillation method (Jackson, 1958).

To determine total P and K, 1 g air dry sample was digested with diacid mixture (1:2 perchloric acid - nitric acid mixture) (Jackson, 1958). The digested material was filtered and made upto 50 ml. Total P content from the extract was determined by the Vanadomolybdophosphoric yellow colour method in nitric acid system (Jackson, 1958). Total K in the acid extract was determined using flame photometer (Jackson, 1958).

Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus was extracted using Bray No.1 extractant and determined by ascorbic acid method (Watanabe and Olson, 1965). Available K was extracted using neutral 1N ammonium acetate and determined using a flame photometer (Jackson, 1958).

Nutrient content analysis in different plant parts

Three plants from each replication were randomly selected and plant was separated as shoot (above ground portion) and root (under ground portion). The samples after drying were powdered in Willey mill. The fine powder was used for the estimation of various nutrient elements like Nitrogen, Phosphorus and Potassium. The standard procedure adopted for the nutrient content analysis were described here under.

Nitrogen

Nitrogen content in fresh samples was determined by digesting 0.1 g of sample in 5 ml of concentrated sulphuric acid using digestion mixture (Sodium sulphate : Copper sulphate in 10 : 4 ratio) and nitrogen in the digest was determined by Kjeldahali's method (Jackson, 1958).

Phosphorus

A known quantity (0.5 g) of the powdered sample was digested in triacid mixture (Nitric acid : Sulphuric acid : Perchloric acid in 10:1:3 ratio) and the digest was made upto 50 ml. A known quantity of the sample was taken to determine the P content colorimetrically by the Vanadomolybdo phosphoric yellow colour method (Jackson, 1958). The colour intensity was read in a photoelectric colorimeter using blue filter.

Potassium

An aliquot from the triacid extract was taken to read potassium using flame photometer (Jackson, 1958).

Statistical analysis

The data were subjected to analysis of variance. Since comparison among species to determine the effect of different rooting media is meaningless as their growth habit are vastly different, completely randomised design is used. Statistical analysis of various plant characters was done with PC using MSTAT-C package.

Results

RESULTS

The present series of studies were carried out with an objective of standardising the most suitable media for the best growth of different tree seedlings in the nursery for agroforestry planting. The salient results of the studies are presented below.

EXPERIMENT-I

In this experiment, the effect of eight different rooting media on the growth behaviour of seven forest tree seedlings is presented in two headings viz. biometric observations and soil chemical characteristics.

1 ***Ailanthus triphysa***

1.1 Biometric observations

1.1.1 Shoot length

Rooting media significantly influenced the shoot length of *Ailanthus* seedlings (Fig.2). At 90 DAS, largest increase of shoot length was observed in soil and FYM in the ratio of 2/3 and 1/3 each. Compared to the control, this was 109 per cent more. Soil, sand and FYM in the proportion of 1/3 each also significantly increased the shoot length by 54 per cent. Rest of the treatments were not effective in increasing the shoot length.

At 180 DAS, largest increase was observed in soil, sand and FYM in the proportion of 1/3 each. This was 37 per cent more compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 gave rise to 26 per cent increase in shoot length. The other rooting media did not have any influence.

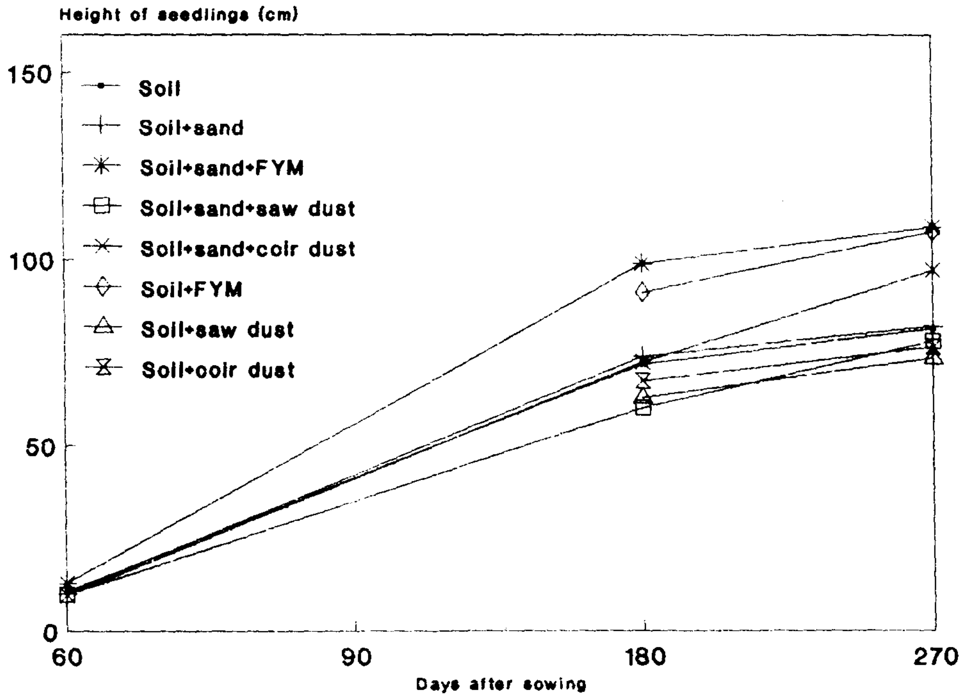


Fig.2. Effect of rooting media on the height of ailanthus

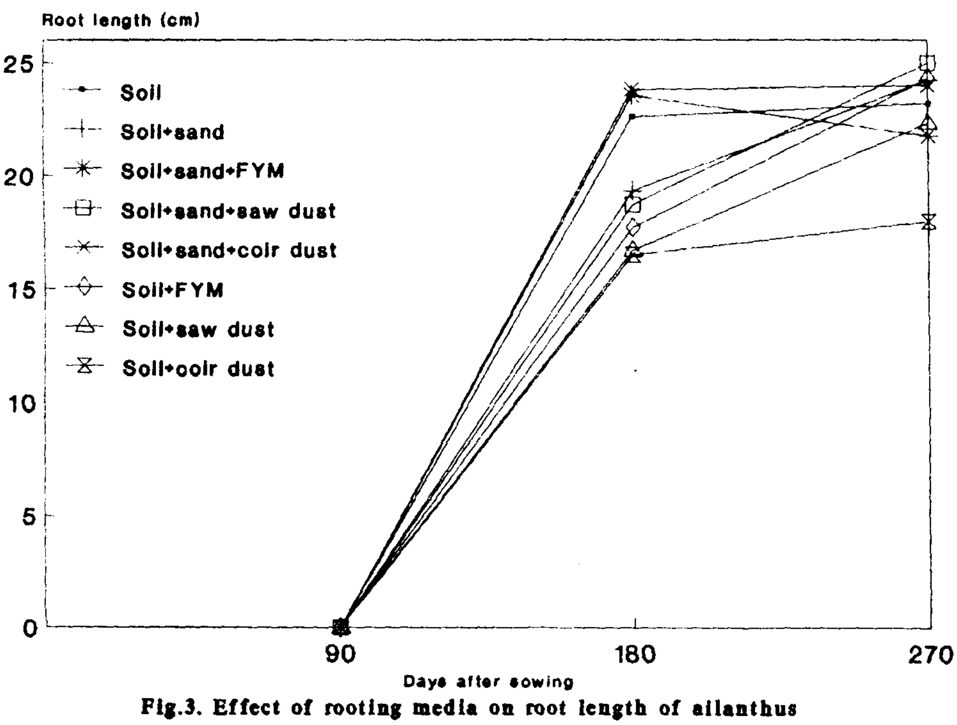


Fig.3. Effect of rooting media on root length of ailanthus

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each significantly increased the shoot length. The increase was 33 per cent more compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 each was the next best resulting in an increase of 32 per cent, compared to the control. Soil, sand and coir dust in the proportion of 1/3 each also influenced the height of seedlings (19%). The other four rooting media had no influece on the height growth in *Ailanthus*.

1.1.2 Root length

Significant difference in the root length was observed in *Ailanthus* only at 180 DAS. The rooting media of soil and saw dust in the ratio of 2/3 and 1/3 each significantly reduced the root length. Soil and coir dust in the ratio of 2/3 and 1/3 each also significantly reduced the root length compared to the control. All the other five treatments did not significantly influence the root length (Fig.3).

At 90 DAS and 270 DAS, none of the rooting media had any influence on the root length of *Ailanthus*.

1.1.3 Leaf number

At 90 DAS, rooting media did not have any significant influence on the number of functional leaves of *Ailanthus* (Fig.4).

At 180 DAS, soil and saw dust in the ratio of 2/3 and 1/3 each significantly reduced the number of functional leaves. The rooting medium of soil and sand in the ratio of 2/3 and 1/3 each also resulted in reduction of leaf number compared to the control. The rooting medium of soil and coir dust in the ratio of 2/3

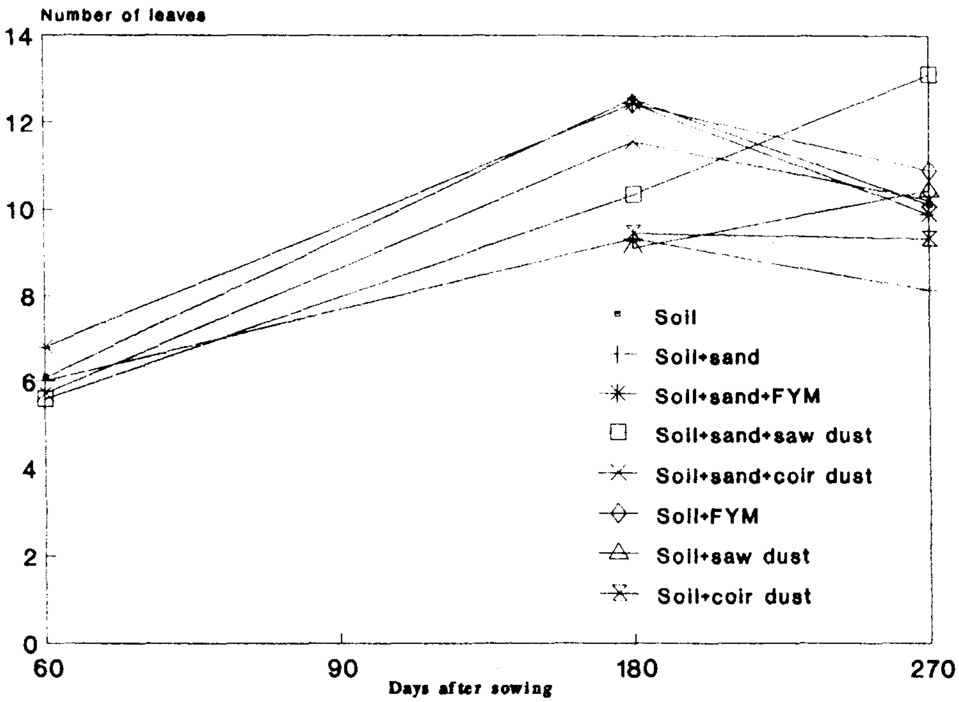


Fig.4. Effect of rooting media on the number of leaves

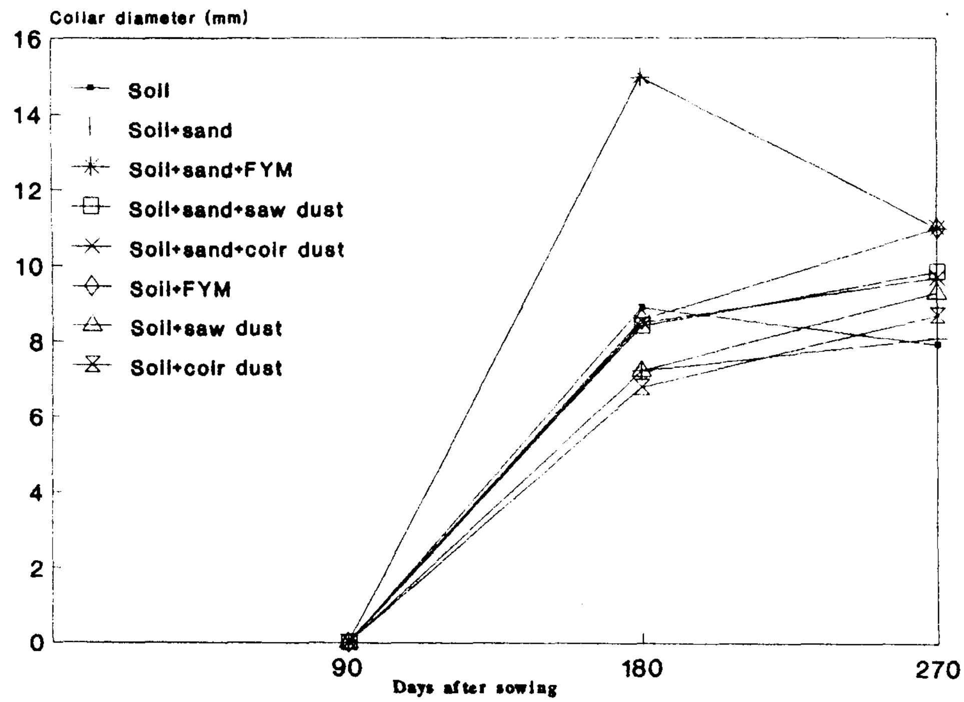


Fig.5. Effect of rooting media on the collar diameter

and 1/3 each was also found to have reduced the number of functional leaves significantly. The remaining four treatments did not influence the leaf number at all.

At 270 DAS, the different rooting media did not have any influence on the number of functional leaves in *Ailanthus*.

1.1.4 Collar diameter

Significant difference in the collar diameter of *Ailanthus* seedlings was observed due to different rooting media (Fig. 5). At 90 DAS largest collar diameter of *Ailanthus* was observed due to the rooting media of soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each. These treatments were significantly superior to all the other rooting media treatments.

At 180 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each had greatly influenced the collar diameter in *Ailanthus*. The increase was found to be 68 per cent when compared to the control. All the remaining six treatments did not influence the collar diameter of *Ailanthus*.

At 270 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each and the treatment with soil and FYM in the ratio of 2/3 and 1/3 each had the same influence on the collar diameter. These treatments increased collar diameter to the extent of 39 per cent compared to the control. Another effective rooting media was soil, sand and saw dust in the proportion of 1/3 each. All the other four treatments had no influence on the collar diameter in *Ailanthus* when compared to the control.

1.1.5 Shoot dry weight

Data pertaining to the influence of different rooting media on the shoot dry weight of *Ailanthus* are given in Table 1. At 90 DAS, largest increase in shoot dry weight was observed due to the rooting media of soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each. Rest of the treatments were at par.

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each significantly increased the shoot dry weight of *Ailanthus* by 156 per cent compared to the control. Other media did not have any influence on the shoot dry weight.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each greatly increased the shoot dry weight of *Ailanthus* by 118 per cent compared to the control. The second best treatment was soil and FYM in the ratio of 2/3 and 1/3 each. The increase was 95 per cent compared to the control. The rooting medium of soil, sand and coir dust in the proportion of 1/3 each increased the shoot dry weight by 76 per cent. The remaining rooting media did not have any effect on the shoot dry weight.

1.1.6 Root dry weight

Even though significant differences in root dry weight was observed at 90 DAS due to the influence of different rooting media, there was no definite trend.

At 180 DAS, sand, soil and FYM in the proportion of 1/3 each gave rise to 127 per cent increase in the root dry weight compared to the control. The other rooting media did not have any influence on the root dry weight.

Table 1. Biomass accumulation of ailanthus seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight (g)			Root dry weight (g)			Leaf dry weight (g)			Root:Shoot ratio		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
Soil alone	0.24	4.39	6.92	0.18	1.23	2.51	0.53	4.86	4.60	0.65	0.32	0.30
Soil+sand	0.19	2.73	7.27	0.08	0.92	3.03	0.56	3.66	3.48	0.62	0.26	0.30
Soil+sand+FYM	0.71	11.24	15.09	0.16	2.80	4.52	1.46	10.58	8.64	0.40	0.24	0.20
Soil+sand+saw dust	0.18	3.98	10.77	0.07	1.42	4.78	0.31	4.53	7.37	0.75	0.32	0.33
Soil+sand+coir dust	0.26	5.26	12.18	0.07	1.62	4.19	0.47	7.04	9.30	0.74	0.34	0.25
Soil + FYM	0.71	5.66	13.55	0.18	1.30	3.94	1.60	6.59	7.30	0.39	0.20	0.23
Soil + saw dust	0.18	3.52	8.56	0.08	1.16	3.06	0.40	5.48	4.86	0.54	0.27	0.30
Soil + coir dust	0.23	3.03	6.29	0.10	1.04	2.83	0.52	3.82	3.54	0.78	0.24	0.25
SEm±	0.053	0.899	1.393	0.031	0.323	0.570	0.136	1.107	1.123	0.0816	0.028	0.024
CD(0.05)	0.153	2.492	3.861	0.089	0.894	1.580	0.392	3.067	3.112	0.2358	0.077	0.085

At 270 DAS, soil, sand and saw dust in the proportion of 1/3 each resulted in an increase of 90 per cent in root dry weight. The other best rooting media were soil, sand and FYM in the proportion of 1/3 each followed by soil, sand and coir dust in the proportion of 1/3 each. All the other rooting media did not have any influence on the root dry weight of *Ailanthus*.

1.1.7 Leaf dry weight

At 90 DAS, largest increase in leaf dry weight was observed due to soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each. These two treatments were significantly superior to the rest of the rooting media treatments which were on par (Table 1).

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each significantly increased in the leaf dry weight. All the remaining six treatments had no influence on the leaf dry weight.

At 270 DAS, soil, sand and coir dust in the proportion of 1/3 each resulted in a significant increase of 102 per cent in leaf dry weight compared to the control. Another effective treatment was soil, sand and FYM in the proportion of 1/3 each. All ther other treatments had no effect on the leaf dry weight.

1.1.8 Root : shoot ratio

Significant difference in the root : shoot ratio was observed due to the influence of different rooting media. At 90 DAS, soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each significantly reduced the root : shoot ratio compared to the control. All the other treatments were on par.

At 180 DAS, largest reduction in root : shoot ratio was observed due to the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each. This was followed by the rooting medium of soil, sand and FYM in the proportion of 1/3 each and soil and coir dust in the proportion of 2/3 and 1/3 each. Rest of the rooting media were not effective (Table 1).

Significant reduction in the root : shoot ratio was observed in *Ailanthus* due to the rooting medium treatment of soil, sand and FYM in the proportion of 1/3 each compared to the control at 270 DAS. Rest of the treatments were not effective in influencing the root : shoot ratio.

1.2 Soil chemical characteristics

1.2.1 pH and EC

Physico-chemical properties of the soil tested showed significant variation except for soil pH (Table 2) and EC which ranged from 4.6 to 4.9 and 0.045 dSm^{-1} to 0.127 dSm^{-1} respectively.

1.2.2 Organic carbon

Soil organic carbon status of seedlings grown in coir dust was significantly higher (1.54%) than the rest, closely followed by control (1.51%) which again was statistically superior to all other treatments. The lowest soil organic carbon status was recorded by seedlings grown in soil + sand + FYM.

Table 2. Soil chemical properties (0-15 cm soil layer) under *Ailanthus triphysa* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P(%)	Total K (%)
Soil alone	4.6	0.051	1.514	4.760	225.00	0.364	0.055	0.550
Soil + sand	4.9	0.045	1.143	9.180	138.33	0.392	0.053	0.375
Soil+sand+FYM	4.6	0.127	0.867	35.020	133.33	0.227	0.062	0.325
Soil+sand+sow dust	4.5	0.083	1.076	9.520	237.50	0.284	0.049	0.525
Soil+sand+coir dust	4.6	0.066	1.314	13.600	187.50	0.279	0.057	0.450
Soil 2/3 : FYM 1/3	4.6	0.069	1.002	37.400	158.33	0.196	0.063	0.325
Soil 2/3 : saw dust 1/3	4.5	0.082	1.371	5.100	175.00	0.258	0.046	0.425
Soil 2/3 : coir dust 1/3	4.7	0.054	1.543	6.460	229.16	0.335	0.049	0.500
SEm±	0.1536	0.0392	0.0736	0.4026	29.3521	0.0156	0.0002	0.0120
CD(0.05)	NS	NS	0.223	1.220	88.94	0.047	0.0006	0.036

1.2.3 Nitrogen

Different rooting media produced significant influence on the percentage of total N. Highest content was observed in soil + sand followed by soil alone and soil + coir dust. The least concentration was noticed in soil + FYM alone and soil + sand + FYM.

1.2.4 Phosphorus

Both available and total P was significantly higher in soil + FYM and in soil + sand + FYM. Soil + saw dust and soil + sand + saw dust was the most inferior medium with respect to P content. The rest of the treatments were intermediate with this aspect.

1.2.5 Potassium

As regards to K, highest concentration was found in soil + sand + saw dust followed by soil + coir dust and soil alone. The least concentration was noticed in soil + sand + FYM.

2 ***Albizia falcataria***

2.1 Biometric observations

2.1.1 Shoot length

Highly significant differences were observed in the shoot length of *Albizia* at 90 DAS when grown in eight different types of rooting media (Fig. 6). Rooting media containing soil, sand and FYM 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 gave rise to largest increase in shoot length. Soil and saw dust in the ratio of 2/3 and 1/3 each and soil and coir dust in the ratio of 2/3 and 1/3 each

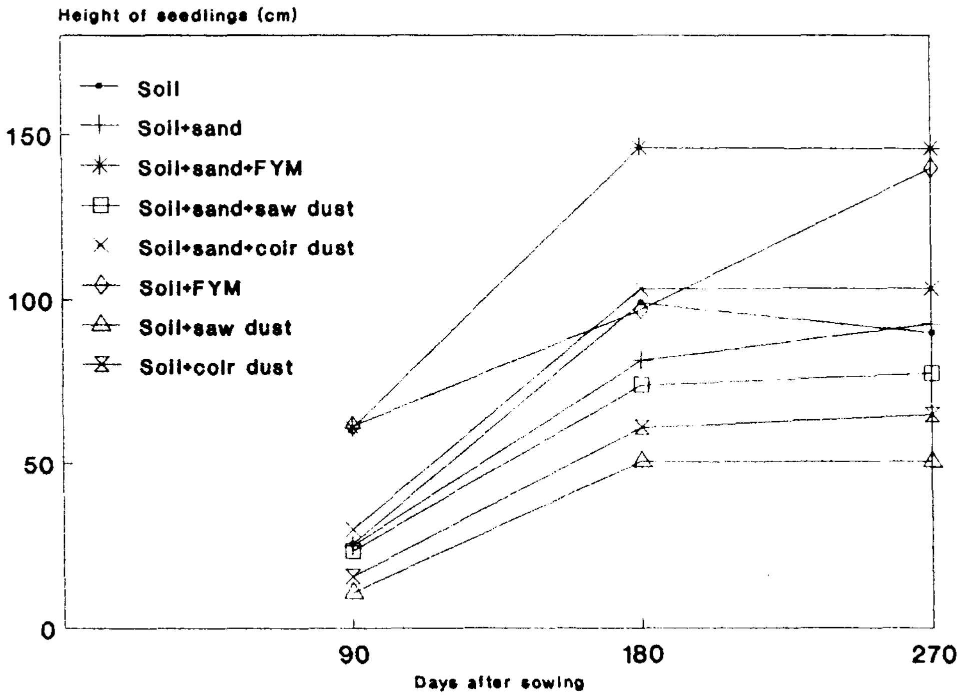


Fig.6. Effect of rooting media on the height of albizia

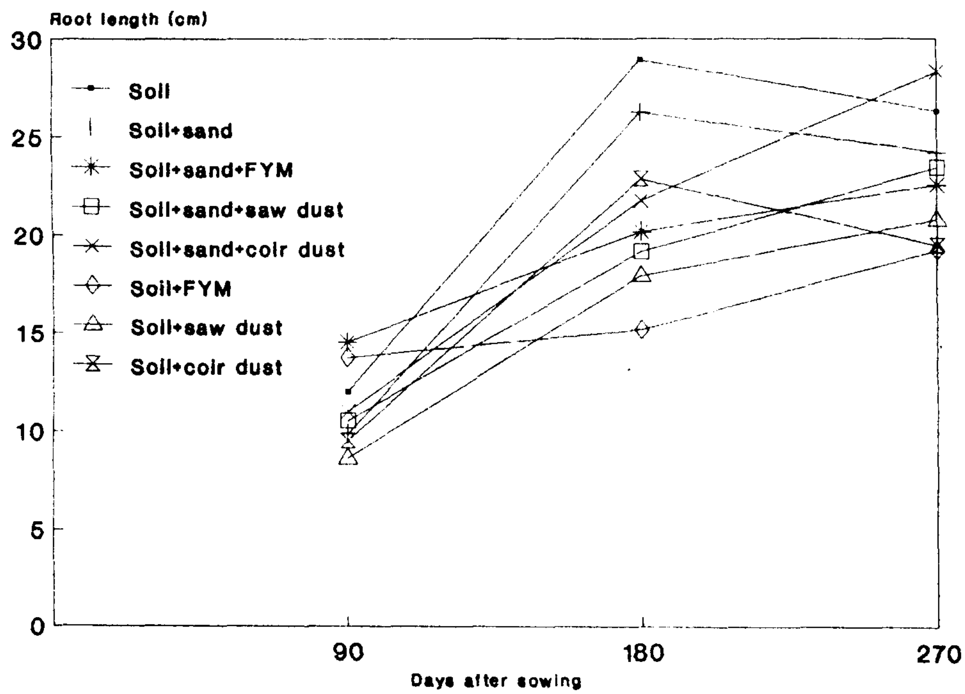


Fig.7. Effect of rooting media on the root length of albizia

significantly reduced the shoot length. The other treatments did not have any influence.

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to 47 per cent increase in the shoot length of *Albizia* compared to control. Soil and saw dust in the ratio of 2/3 and 1/3 and soil and coir dust in the ratio of 2/3 and 1/3 resulted in significant reduction in the shoot length compared to the control. The other treatments did not have any influence.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to largest increase (62%). Soil and FYM in the ratio of 2/3 and 1/3 each increased the shoot length by 55 per cent compared to the control. Soil and saw dust in the proportion of 2/3 and 1/3 and soil and coir dust in the proportion of 2/3 and 1/3 resulted in significant reduction in the shoot length of *Albizia* compared to the control. The other treatments did not have any influence.

2.1.2 Root length

At 90 DAS, the root length of *Albizia* was longest when grown in the rooting medium of soil, sand and FYM in the proportion of 1/3 each (Fig. 7). This was closely followed by the seedlings grown in the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each and soil alone. All the other treatments were significantly inferior.

Root length of *Albizia* was not significant affected at 180 DAS and at 270 DAS by the different rooting media.

2.1.3 Number of leaves

At 90 DAS and at 180 DAS, the rooting media did not have any significant effect on the number of leaves (Fig. 8).

At 270 DAS, significant differences were observed in the number of leaves of *Albizia*. Largest increase in the number of leaves was found in the rooting medium of soil and coir fibre in the ratio of 2/3 and 1/3 each. Rest of the treatments did not have any influence on the number of leaves.

2.1.4 Collar diameter

Rooting media significantly influenced the collar diameter of *Albizia* seedlings (Fig. 9). At 90 DAS, soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each resulted in highly significant increase in the collar diameter. On an average this increase was 88 per cent more compared to the control. All the other treatments were on par compared to the control.

Rooting media did not have any significant effect on the collar diameter of *Albizia* seedlings at 180 DAS.

At 270 DAS, the rooting medium of soil and saw dust in the ratio of 2/3 and 1/3 significantly reduced the collar diameter of *Albizia* seedlings. Other treatments did not have any effect.

2.1.5 Shoot dry weight

At 90 DAS, the rooting media of soil, sand and FYM in the proportion

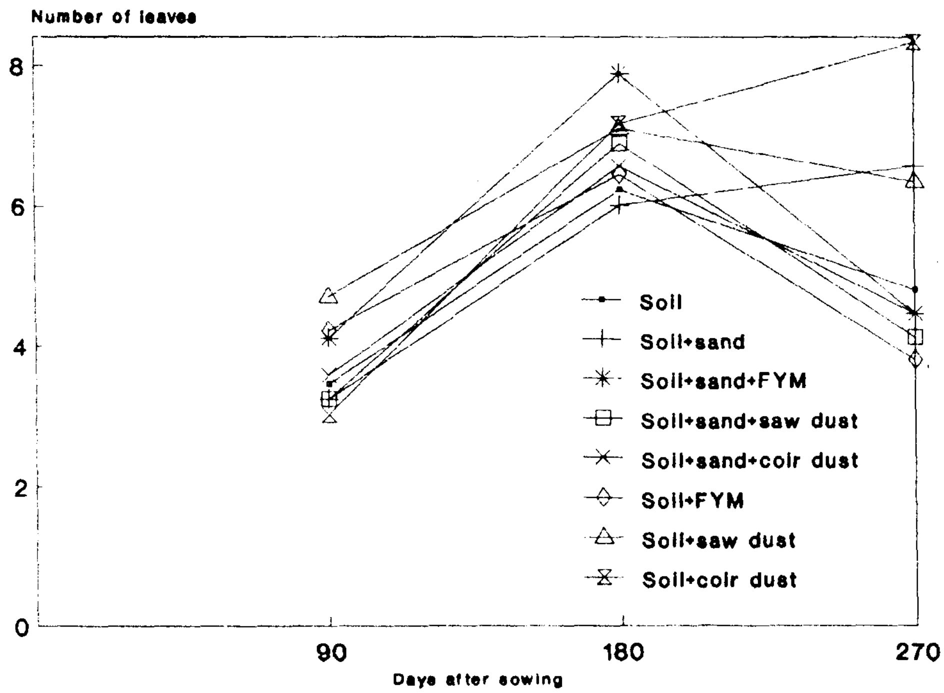


Fig.8. Effect of rooting media on the number of leaves

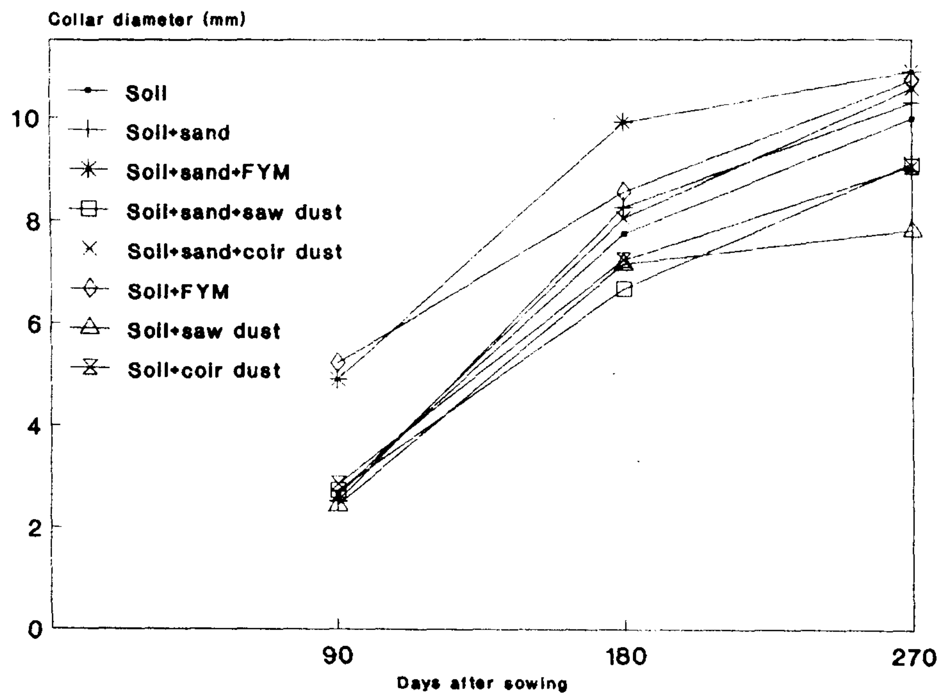


Fig.9. Effect of rooting media on the collar diameter

of 1/3 each, and soil and FYM in the ratio of 2/3 and 1/3 each gave rise to largest increase in shoot dry weight of *Albizia*. The other rooting media did not have any influence on the shoot dry weight of *Albizia* (Table 3).

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each more than doubled the shoot dry weight of *Albizia* compared to control. The remaining treatments did not have any influence on the shoot dry weight.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each, and soil and FYM in the ratio of 2/3 and 1/3 each significantly increased the shoot dry weight by about 85 per cent compared to the control. The remaining treatments did not have any influence.

2.1.6 Root dry weight

At 90 DAS, the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each gave rise about nine times increase in the root dry weight compared to the control. The other rooting media did not have any influence on the root dry weight (Table 3).

At 180 DAS and 270 DAS, the rooting media did not have any influence on the root dry weight of *Albizia*.

2.1.7 Leaf dry weight

Data pertaining to the influence of different rooting media on the leaf dry weight of *Albizia* are given in Table 3. At 90 DAS, largest increase in leaf dry weight was observed in the rooting media of soil and FYM in the proportion of 2/3 and 1/3 each, the increase being in the order of four times compared to the control.

Table 3. Growth characters of albizia seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight (g)			Root dry weight (g)			Leaf dry weight (g)			Root:Shoot ratio	
	90	180	270	90	180	270	90	180	270	180	270
	(Days after sowing)										
Soil alone	0.19	6.15	11.16	0.07	1.51	4.08	0.46	5.91	4.84	0.30	0.29
Soil+sand	0.20	7.12	12.17	0.05	1.92	3.68	0.37	8.83	7.91	0.38	0.28
Soil+sand+FYM	1.43	14.19	20.34	0.30	2.68	4.64	1.61	10.41	3.78	0.14	0.15
Soil+sand+saw dust	0.21	3.87	9.08	0.07	1.02	3.50	0.56	5.76	3.14	0.27	0.32
Soil+sand+coir dust	0.34	7.64	13.55	0.08	1.63	4.39	0.50	6.85	5.40	0.23	0.28
Soil + FYM	1.45	10.11	20.98	0.67	2.06	4.62	2.38	8.31	3.44	0.18	0.14
Soil + saw dust	0.10	2.90	4.53	0.05	0.97	2.88	0.49	6.58	5.15	0.42	0.44
Soil + coir dust	0.19	4.33	8.29	0.09	1.66	3.42	0.72	8.87	8.41	0.44	0.35
SEm±	0.155	2.031	2.591	0.147	0.473	0.748	0.274	1.930	1.008	0.065	0.034
CD (0.05)	0.429	5.629	7.181	0.405	NS	NS	0.762	NS	2.792	0.182	0.094

The rooting medium of soil, sand and FYM in the proportion of 1/3 each also significantly increased the leaf dry weight by 2.5 times compared to control. The other rooting media did not have any influence.

At 180 DAS, leaf dry weight was not influenced significantly by different rooting media. However, at 270 DAS, the rooting media of soil and sand in the ratio of 2/3 and 1/3 each and soil and coir dust in the ratio of 2/3 and 1/3 each gave rise to largest increase in the leaf dry weight compared to control. The other treatments did not have any influence on the leaf dry weight of *Albizia*.

2.1.8 Root : shoot ratio

Significant difference in the root : shoot ratio of *Albizia* seedlings was observed both at 180 DAS and 270 DAS (Table 3). The rooting media containing FYM resulted in lowest root : shoot ratio. Largest root : shoot ratio was observed in the rooting media containing soil and either saw dust or coir dust in the ratio of 2/3 and 1/3 respectively.

2.2 Soil chemical characteristics

2.2.1 Soil pH and EC

Treatments do not differ significantly with respect to pH. As regards to EC, soil + sand + FYM registered a high significant value (Table 4).

2.2.2 Organic carbon

With regard to organic carbon, the highest value was recorded by seedlings grown in soil + saw dust. The second highest value was registered by soil + FYM and soil + sand + FYM.

Table 4. Soil chemical properties (0-15 cm soil layer) under *Albizia falcataria* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.4	0.49	1.09	6.12	154.17	0.228	0.60	0.350
Soil + sand	4.6	0.053	0.76	3.40	83.33	0.153	0.05	0.275
Soil+sand+FYM	4.7	0.207	1.19	17.00	141.67	0.220	0.06	0.375
Soil+sand+saw dust	4.5	0.090	0.055	7.82	154.17	0.117	0.05	0.425
Soil+sand+coir dust	4.5	0.069	0.67	6.12	183.33	0.130	0.05	0.475
Soil 2/3 : FYM 1/3	4.6	0.068	1.20	8.05	179.17	0.235	0.06	0.400
Soil 2/3 : saw dust 1/3	4.5	0.086	1.48	5.80	79.17	0.256	0.06	0.325
Soil 2/3 : coir dust 1/3	4.7	0.062	0.73	9.86	129.17	0.149	0.06	0.300
SEm±	0.2014	0.0452	0.036	0.40	23.15	0.007	0.0002	0.010
CD(0.05)	NS	0.137	0.109	1.21	70.14	0.022	0.0006	0.030

2.2.3 Nitrogen

The highest N content was noted in the medium containing soil + saw dust (0.26%). In other media, N content decreased in the order of FYM alone, soil alone and soil + sand + FYM.

2.2.4 Phosphorus

The P content was the highest (17 ppm) for soil + sand + FYM. In the case of the other treatments under study, all of them produced more or less similar effects regarding the P content.

2.2.5 Potassium

Both total and available K were highest in the media containing soil + sand + coir dust closely followed by FYM alone and soil + sand + saw dust. The media containing soil + saw dust was the most inferior with this respect.

3 ***Casuarina equisetifolia***

3.1 Biometric observations

3.1.1 Shoot height

The observations on the effect of various treatments on the height of *Casuarina* seedlings are illustrated in Fig. 10. The seedlings showed significant differences due to treatment effect.

At 90 DAS, rooting media of soil and FYM in the ratio of 2/3 and 1/3 resulted in 163 per cent increase in seedling height compared to the control. Soil, sand and FYM in the proportion of 1/3 each resulted in 129 per cent more height

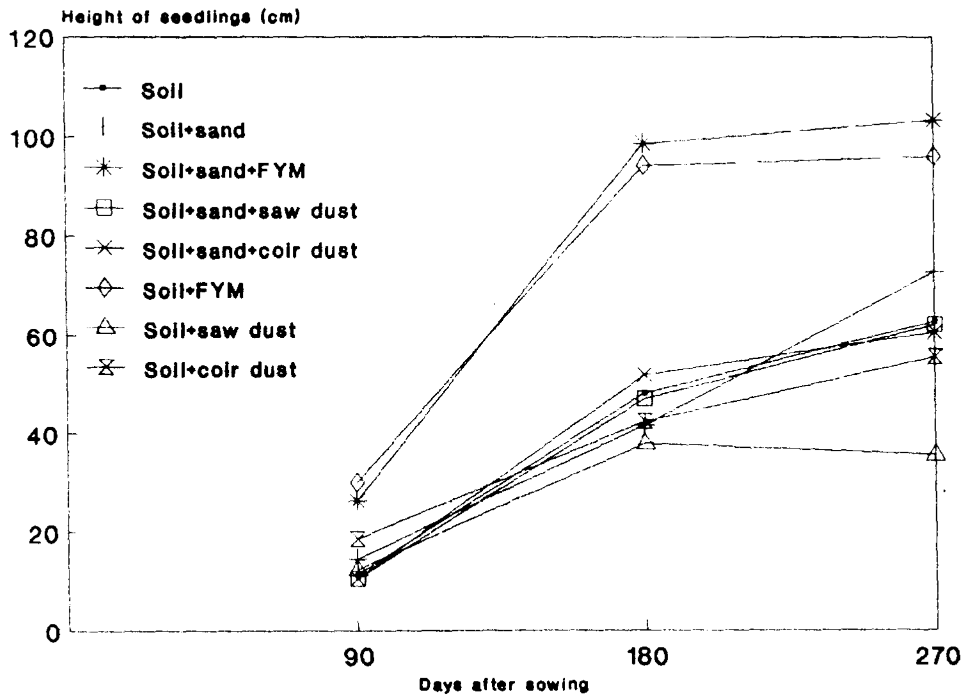


Fig.10. Effect of rooting media on the height of casuarina

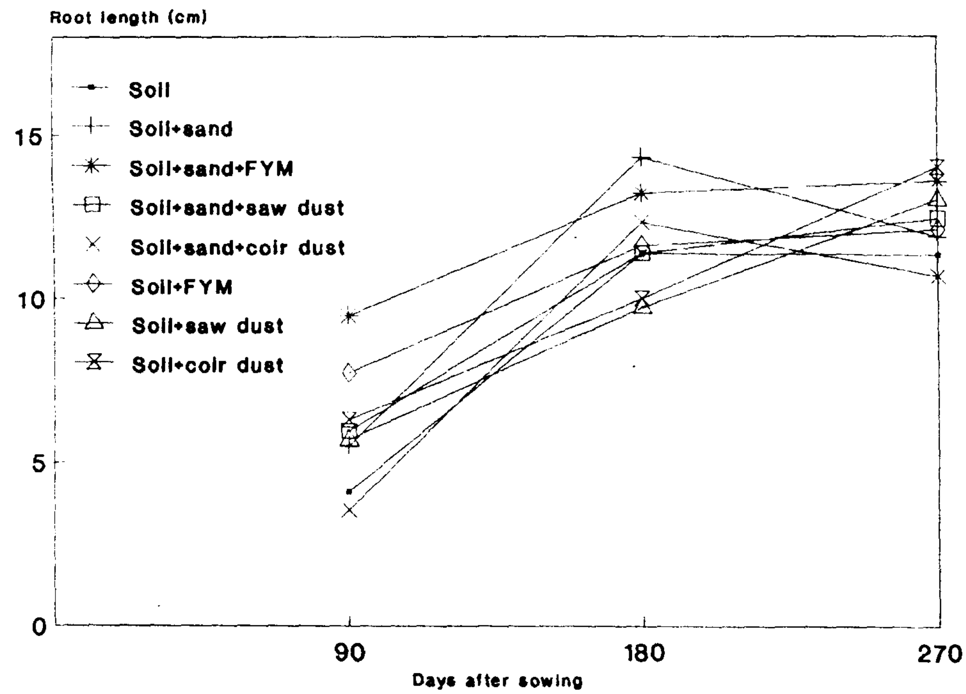


Fig.11. Effect of rooting media on the root length

growth. Soil and coir fibre in the ratio of 2/3 and 1/3 resulted in 61 per cent more height. The other rooting media did not have any influence.

The rooting media of soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each almost doubled the height of *Casuarina* compared to the control at 180 DAS. The other treatments did not have any influence.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each increased the height of *Casuarina* seedlings by 65 per cent. Soil and FYM in the ratio of 2/3 and 1/3 each increased the height by 53 per cent. Rest of the rooting media did not have any significant influence.

3.1.2 Root length

Rooting media significantly influenced the root length of *Casuarina* (Fig. 11). At 90 DAS, root length in soil, sand and FYM in the proportion of 1/3 each significantly increased the root length compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 also resulted in significant increase in the root length. Rest of the rooting media did not have any influence.

However, at 180 DAS and 270 DAS, root length of *Casuaria* was not significantly affected by the rooting media.

3.1.3 Number of needles

At 90 DAS, the number of needles of *Casuarina* increased by 168 per cent when grown in the rooting medium of soil, sand and FYM in the proportion of 1/3 compared to the control (Fig. 12). Soil and FYM in the ratio of 2/3 and 1/3 increased the number of needles by 214 per cent. The other rooting media did not have any influence.

At 180 DAS, the number of needles of *Casuarina* increased significantly by 75 per cent when grown in soil, sand and FYM in the proportion of 1/3 each while soil and FYM in the ratio of 2/3 and 1/3 increased the number of needles of *Casuarina* by 49 per cent when compared to the control. The other treatments did not have any significant effect.

At 270 DAS, the number of needles was not significantly influenced by the rooting media.

3.1.4 Collar diameter

Different rooring media significantly influenced the collar diameter of *Casuarina* seedlings (Fig. 13). At 90 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each almost doubled the collar diameter compared to the control. Soil and coir fibre in the ratio of 2/3 and 1/3 each also doubled the collar diameter. All the other treatments were on par compared to the control.

At 180 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each increased the collar diameter by 65 per cent and soil and FYM in the ratio of 2/3 and 1/3 increased the collar diameter by 55 per cent. The other treatments did not have any influence.

Similar results were obtained at 270 DAS also, though the magnitude of difference was lesser.

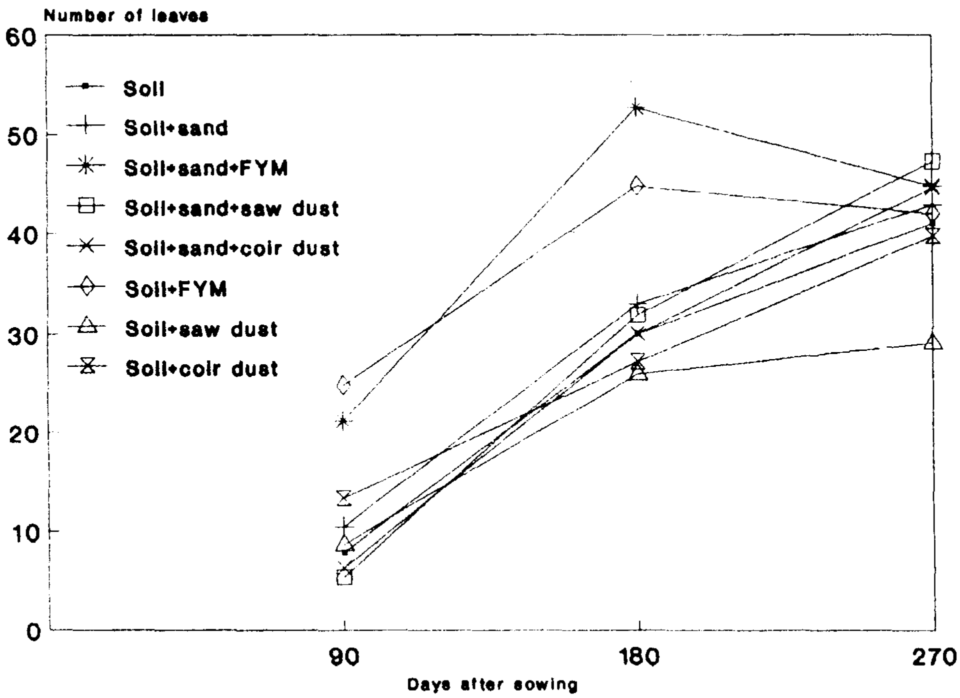


Fig.12. Effect of rooting media on the number of needles

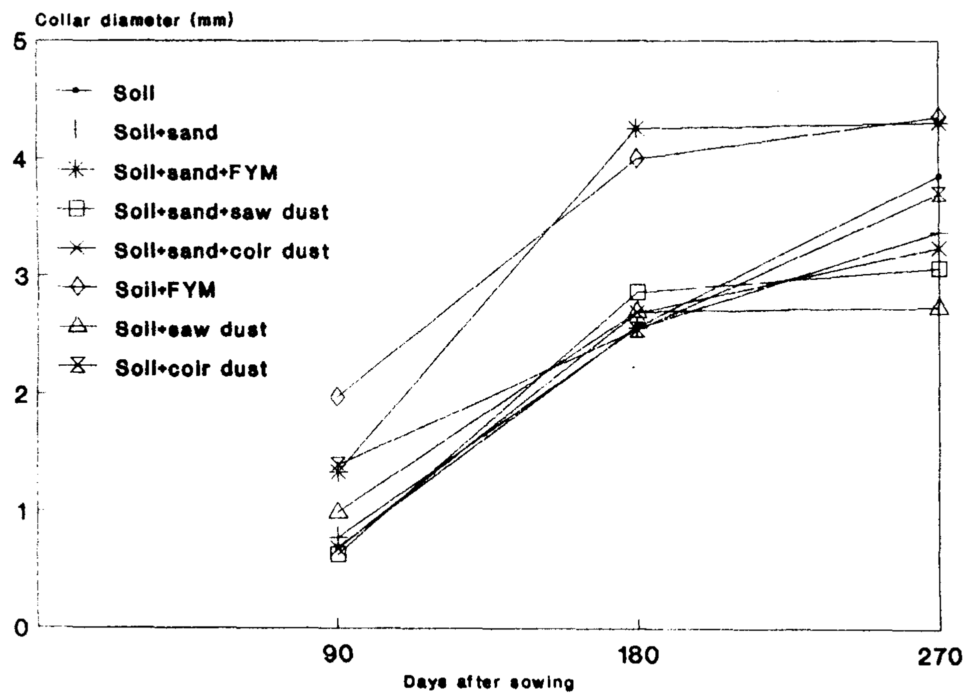


Fig.13. Effect of rooting media on the collar diameter

3.1.5 Shoot dry weight

At 90 DAS, the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 gave rise to largest increase in the shoot dry weight of *Casuarina*, this being about six times over the control (Table 5). Soil, sand and FYM in the proportion of 1/3 each also resulted in about 3 times increase over control. The other rooting media did not have any influence on the shoot dry weight of *Casuarina.*

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each significantly increased the shoot dry weight by 304 per cent compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 increased the shoot dry weight by 231 per cent. The other rooting media did not have any influence.

At 270 DAS, the rooting medium of soil and FYM in the proportion of 2/3 and 1/3 each significantly increased the shoot dry weight by 47 per cent compared to the control. The remaining rooting media did not have any influence on the shoot dry weight of *Casuarina*.

3.1.6 Root dry weight

At 90 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each gave rise to 175 per cent more increase in the root dry weight compared to control. The other rooting media did not have any influence on the root dry weight of *Casuarina* (Table 5).

At 180 DAS, the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each gave rise to three fold increase increase in the root dry weight compared to the control. Soil, sand and FYM in the proportion of 1/3 each gave rise

Table 5. Growth characters of casuarina seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight (g)			Root dry weight (g)		
	90	180	270	90	180	270
	(Days after sowing)					
Soil alone	0.06	1.45	4.16	0.02	0.22	0.84
Soil + sand	0.07	1.91	3.77	0.02	0.26	0.69
Soil + sand + FYM	0.25	5.86	5.90	0.05	0.55	0.97
Soil + sand + saw dust	0.06	1.51	3.75	0.02	0.25	0.82
Soil + sand + coir dust	0.05	1.70	4.02	0.01	0.26	0.73
Soil + FYM	0.43	4.80	6.13	0.06	0.70	0.86
Soil + saw dust	0.07	1.33	1.36	0.02	0.31	0.88
Soil + coir dust	0.15	1.21	3.58	0.02	0.27	0.85
SEm ±	0.065	0.712	1.007	0.011	0.087	0.235
CD (0.05)	0.168	1.973	2.789	0.029	0.243	NS

to 150 per cent increase in dry weight compared to the control. The remaining treatments did not have any influence on the root dry weight of *Casuarina*.

The root dry weight was not significantly influenced at 270 DAS by any of the rooting media.

3.2 Soil chemical characteristics

3.2.1 pH and EC

Rooting media treatments did not differ in their effect on soil pH. Regarding EC, soil + sand + FYM produced a significantly high value followed by soil + sand. No other medium produced any significant different (Table 6).

3.2.2 Organic carbon

Rooting media containing soil + saw dust recorded significantly higher values (1.51%) followed by soil + coir dust (1.49%). The lowest percentage of organic carbon was registered by soil + sand + FYM 1/3 each and soil (2/3) and FYM (1/3).

3.2.3 Nitrogen

With regard to the N concentration, rooting media containing soil + coir dust recorded the highest percentage. This was followed by soil (2/3) + saw dust (1/3) and soil + sand. The media that exhibited the lowest N content was soil + sand + FYM 1/3 each and soil 2/3 + FYM 1/3.

3.2.4 Phosphorus

Considering the P content, soil + sand + FYM recorded a highly

Table 6. Soil chemical properties (0-15 cm soil layer) under *Casuarina equisetifolia* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.5	0.083	1.11	9.18	75.00	0.227	0.032	0.225
Soil + sand	4.6	0.101	1.33	5.78	87.50	0.256	0.048	0.250
Soil + sand + FYM	4.6	0.211	1.07	40.12	145.83	0.192	0.060	0.400
Soil + sand + saw dust	4.5	0.098	1.07	7.48	191.67	0.209	0.034	0.450
Soil + sand + coir dust	4.6	0.061	1.15	6.46	166.67	0.212	0.036	0.400
Soil + FYM	4.7	0.070	1.09	8.50	150.00	0.194	0.057	0.400
Soil + saw dust	4.5	0.084	1.51	5.10	120.83	0.265	0.032	0.325
Soil + coir dust	4.5	0.076	1.49	4.76	150.00	0.298	0.031	0.300
SEm±	0.1817	0.0124	0.035	0.4018	32.785	0.006	0.0006	0.0116
CD(0.05)	NS	0.037	0.106	1.217	99.34	0.019	0.0018	0.035

significant value. This was 4.5 times higher than the control. The P content of all other media were less than that of control.

3.2.5 Potassium

The concentration of K due to different growing media showed marked variability. Highest content was noticed in soil + sand + saw dust. The second highest was recorded by soil + sand + coir dust. All the media were superior to control with respect to K content.

4 ***Gmelina alborea***

4.1 Biometric observations

4.1.1 Shoot length

Rooting media significantly influenced the shoot length of *Gmèlina* (Fig. 14).

At 90 DAS, soil, sand and FYM in the proportion of 1/3 each increased the shoot length of *Gmelina* by more than three times compared to the control. The remaining three treatments were on par with the control.

At 180 DAS, the five rooting media tried did not have any influence on the shoot length of *Gmelina*. However, at 270 DAS, all the other four rooting media tried significantly influenced the shoot length of *Gmelina* when compared to the control. The largest increase (61%) was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each.

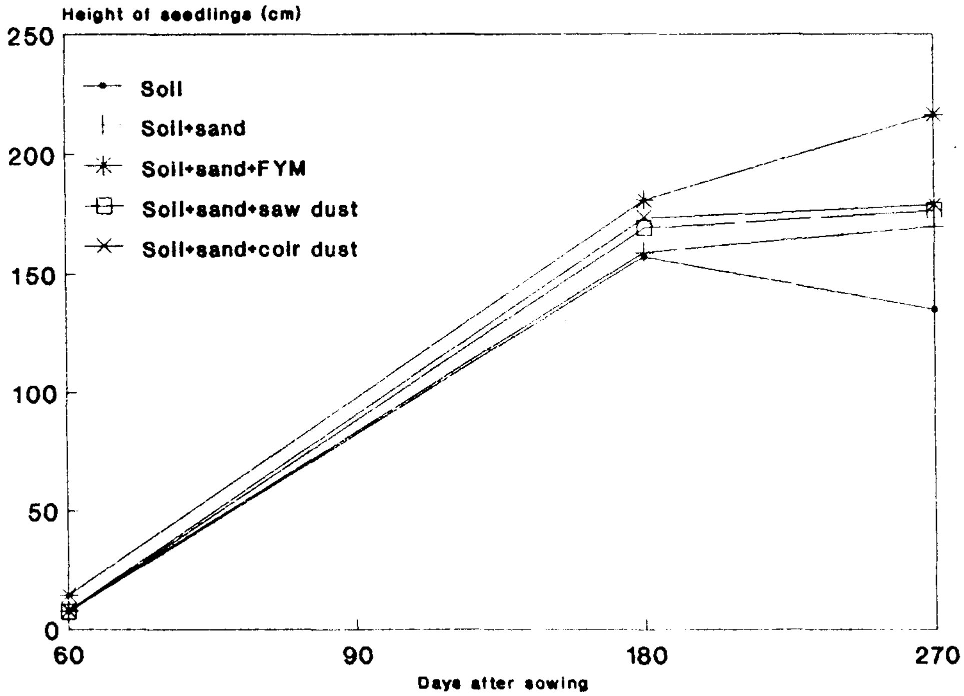


Fig.14. Effect of rooting media on the height of gmelina

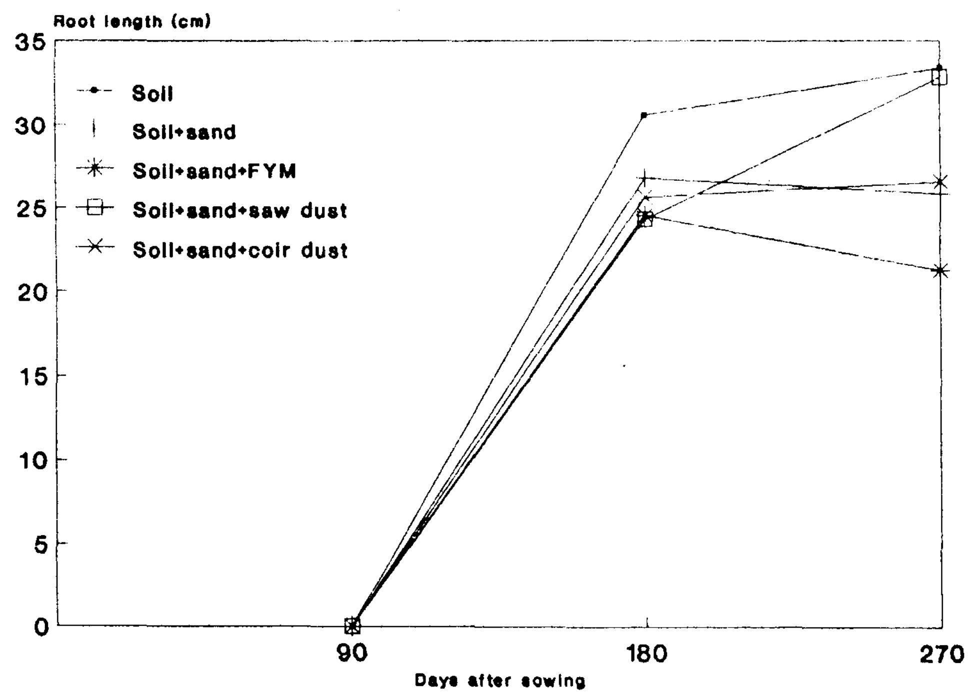


Fig.15. Effect of rooting media on the root length

4.1.2 Root length

At 90 DAS and 270 DAS, the root length of *Gmelina* was significantly influenced by the rooting media tried (Fig.15). Soil, sand and FYM 1/3 each was the superior medium at these stages.

4.1.3 Collar diameter

Data pertaining to the influence of different rooting media on the collar diameter of *Gmelina* are given in Fig.16. At 90 DAS, largest collar diameter of *Gmelina* was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each. This was 108 per cent more compared to the control. The remaining three rooting media were on par compared to the control.

Collar diameter of *Gmelina* was not significantly influenced by the different rooting media at 180 DAS. At 270 DAS, the best medium with respect to this was soil, sand and saw dust.

4.1.4 Number of leaves

At 90 DAS, 180 DAS and 270 DAS, the number of functioning leaves was not significantly influenced by the different rooting media (Fig.17).

4.1.5 Shoot dry weight

Data pertaining to the influence of different rooting media on the shoot dry weight of *Gmelina* are given in Table 7. At 90 DAS, maximum shoot dry weight was observed in the rooting medium of soil, sand and FYM in the proportion

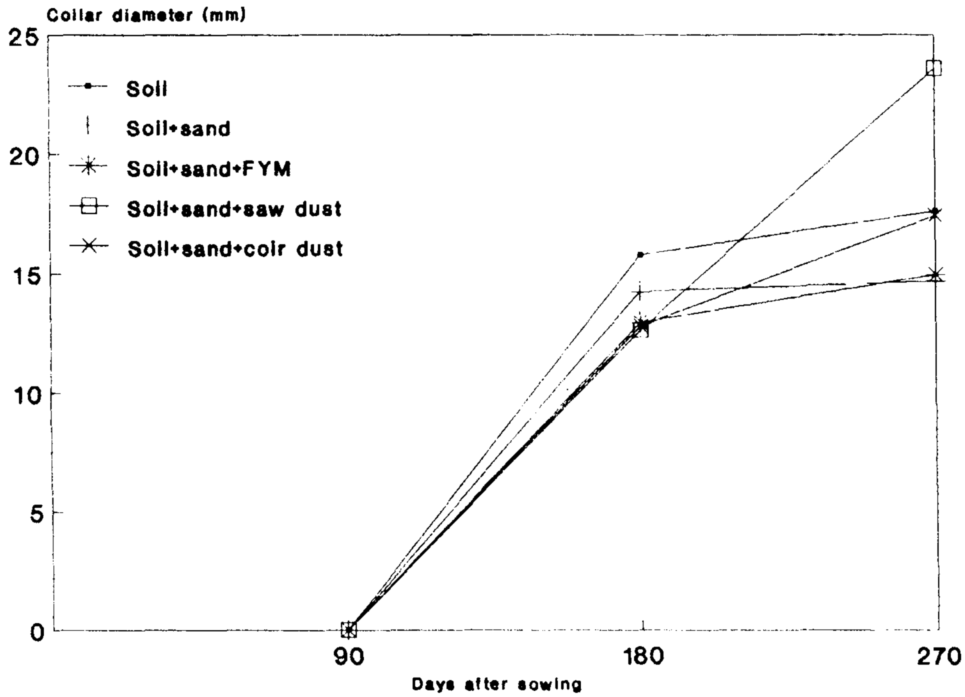


Fig.16. Effect of rooting media on the collar diameter

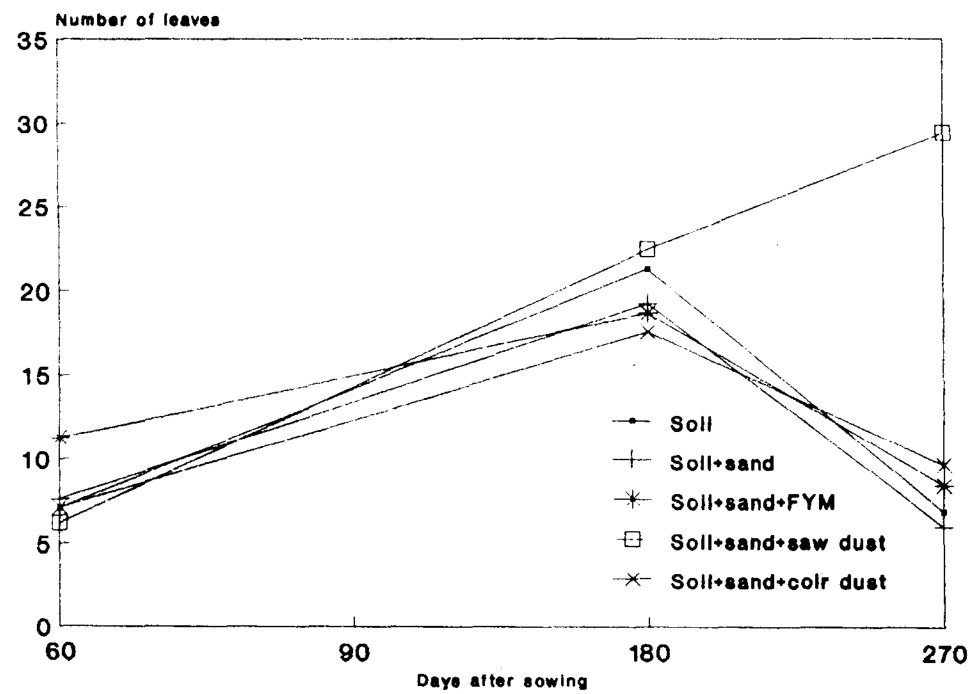


Fig.17. Effect of rooting media on the number of leaves

of 1/3 each. This was 108 per cent more compared to the control. The remaining three rooting media were on par compared to the control.

At 180 DAS, the five rooting media tried did not have any influence on the shoot dry weight of *Gmelina*. However, at 270 DAS, soil, sand and saw dust in the proportion of 1/3 each significantly increased the shoot dry weight compared to the control. The other three treatments did not have any influence.

4.1.6 Root dry weight

Data pertaining to the influence of different rooting media on the root dry weight of *Gmelina* are given in Table 7. At 90 DAS, the rooting media of soil, sand and FYM in the proportion of 1/3 each increased the root dry weight by 3.5 times compared to the control. But at 180 DAS and 270 DAS no significant difference was noticed between the treatments.

4.1.7 Leaf dry weight

At 90 DAS, 4.5 times increase in leaf dry weight of *Gmelina* was observed due to the rooting medium of soil, sand and FYM in the proportion of 1/3 each compared to the control. Rest of the rooting media treatments were not effective in influencing the leaf dry weight compared to the control.

4.1.8 Root : shoot ratio

Data pertaining to the influence of different rooting media on the root : shoot ratio of *Gmelina* are given in Table 7. At 180 DAS, the different rooting media had no significant influence on the root : shoot ratio of *Gmelina*. However, at 270 DAS, root : shoot ratio was significantly influenced by the rooting media

Table 7. Growth characters of gmelina seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight (g)			Root dry weight (g)			Leaf dry weight (g)			Root:Shoot ratio	
	90	180	270	90	180	270	90	180	270	180	270
	(Days after sowing)										
Soil alone	0.80	26.02	23.05	0.25	8.57	19.26	1.41	15.23	2.47	0.20	0.24
Soil+sand	0.45	23.64	28.18	0.15	6.34	11.75	1.35	16.13	2.36	0.18	0.16
Soil+sand+FYM	5.30	24.59	52.41	1.13	5.73	14.66	7.77	8.25	4.67	0.14	0.10
Soil+sand+saw dust	0.34	19.27	88.86	0.20	4.64	33.24	1.14	11.63	10.88	0.15	0.18
Soil+sand+coir dust	0.42	20.11	42.68	0.16	3.70	16.46	1.32	9.14	3.67	0.15	0.15
SEm±	0.834	3.868	15.244	0.204	1.208	6.433	1.539	2.892	2.449	0.021	0.018
CD(0.05)	2.310	NS	42.253	0.566	3.34	17.82	4.266	NS	6.78	NS	0.051

treatments. Compared to the control, all other rooting media treatments significantly reduced the root : shoot ratio of *Gmelina,* largest reduction being noticed in the case of soil, sand and FYM in the proportion of 1/3 each.

4.2 Soil chemical characteristics

4.2.1 pH and EC

Different rooting media treatments do not differ significantly in the case of soil pH and electrical conductivity (Table 8).

4.2.2 Organic carbon

Soil + sand + FYM recorded the highest organic carbon (1.25%) followed by soil + sand + saw dust. The lowest percentage was noticed in soil + sand.

4.2.3 Nitrogen

With regard to total N content, soil + sand + FYM registered the maximum prcentage (0.21%) compared to other media. The lowest content was shown by the media, soil + sand.

4.2.4 Phosphorus

Both available and total P showed a similar trend as in the case of N.

4.2.5 Potassium

With respect to K content, the media that produced a high significant value was soil + sand + FYM. Second highest value was recorded by soil + sand + coir dust. The other two rooting media were on par with the control.

Table 8. Soil chemical properties (0-15 cm soil layer) under *Gmelina alborea* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.6	0.067	0.876	4.42	133.33	0.175	0.035	0.350
Soil + sand	4.5	0.079	0.733	6.46	150.00	0.144	0.039	0.375
Soil + sand + FYM	4.7	0.083	1.248	10.20	254.17	0.206	0.053	0.600
Soil + sand + saw dust	4.4	0.063	0.914	6.80	154.17	0.183	0.045	0.400
Soil + sand + coir dust	4.5	0.049	0.867	6.46	204.17	0.173	0.048	0.475
SEm±	0.1143	0.0319	0.0447	0.0878	13.913	0.009	0.0002	0.0065
CD(0.05)	NS	NS	0.146	0.286	45.35	0.029	0.0006	0.021

5 *Swietenea macrophylla*

5.1 Biometric observations

5.1.1 Shoot length

Rooting media significantly influenced the shoot length of Mahogany (Fig. 18).

At 90 DAS, soil and FYM in the ratio of 2/3 and 1/3 each gave rise to the highest increase of 63 per cent in height growth compared to the control. This was followed by the rooting media of soil, sand and FYM in the proportion of 1/3 each, resulting in 62 per cent increase. Another effective rooting media was soil and coir dust in the ratio of 2/3 and 1/3 (23%). The other rooting media did not have any influence on the height growth of Mahogany.

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to the largest increase (67%) of shoot length. The next best treatment was soil and FYM in the ratio of 2/3 and 1/3 each, which gave rise to 41 per cent increase in shoot length compared to control. The other rooting media did not have any influence.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each resulted in an increase in shoot length of 24 per cent compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 also significantly increased (20%) the height growth. Soil and saw dust in the ratio of 2/3 and 1/3 resulted in a decrease in shoot length compared to the control. Rest of the treatments did not have any influence on the height.

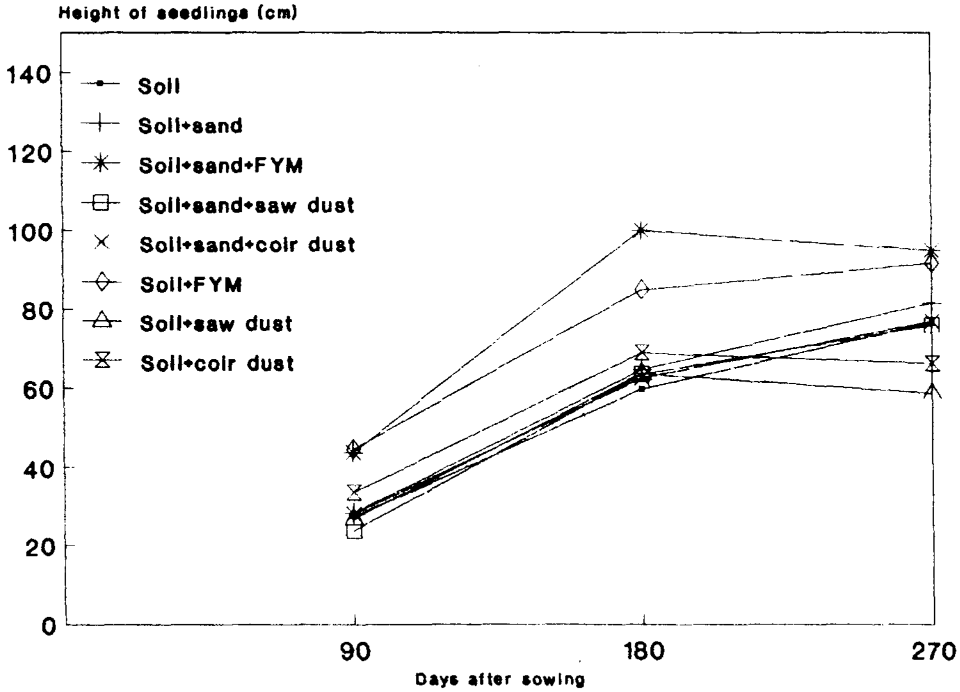


Fig.18. Effect of rooting media on the height of mahogany

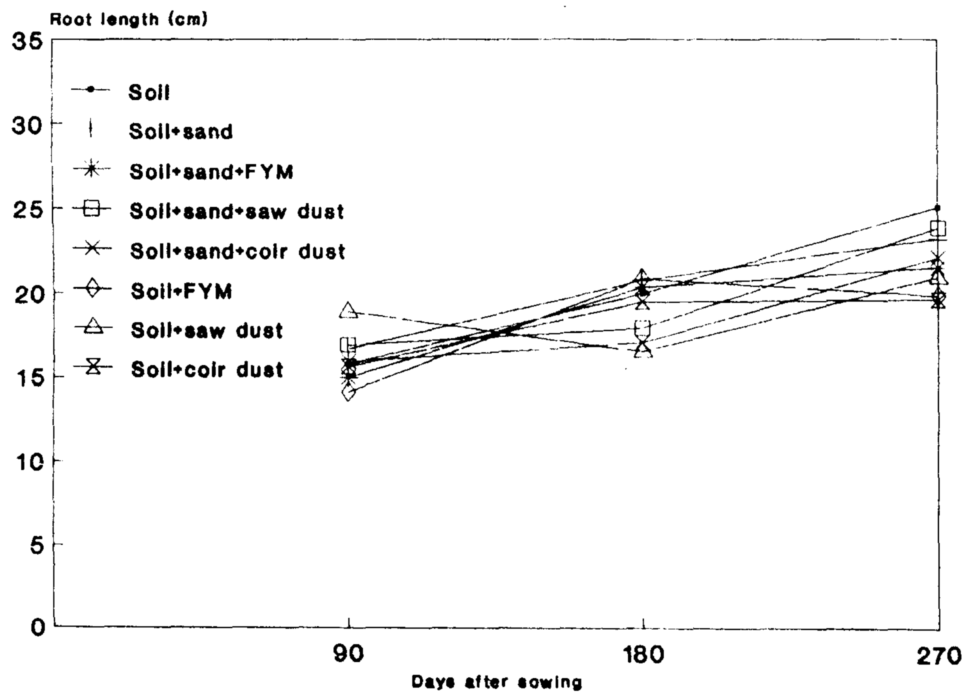


Fig.19. Effect of rooting media on the root length

5.1.2 Root length

Data pertaining to the influence of different rooting media on the root length of Mahogany are given in Fig.19. Soil (2/3) : saw dust (1/3), soil (2/3) : FYM (1/3) and soil alone recorded the highest mean value at 90, 180 and 270 DAS respectively.

5.1.3 Leaf number

Rooting media significantly influenced the number of functional leaves of Mahogany seedlings (Fig. 20).

At 90 DAS, soil, sand and FYM in the proportion of 1/3 each resulted in the highest number of functional leaves. Soil and FYM in the ratio of 2/3 and 1/3 each also resulted in significant increase in the number of functional leaves. The remaining treatments did not have any influence.

The different rooting media did not have any influence on the number of functional leaves of mahogany at 180 DAS. Eventhough significant differences were found in the number of functional leaves due to the different rooting media at 270 DAS, the differences were erratic.

5.1.4 Collar diameter

Rooting media significantly influenced the collar diameter of Mahogany seedlings (Fig. 21).

At 90 DAS, significant increase in the collar diameter was observed due to rooting media of soil, sand and FYM in the proportion of 1/3 each, soil and FYM

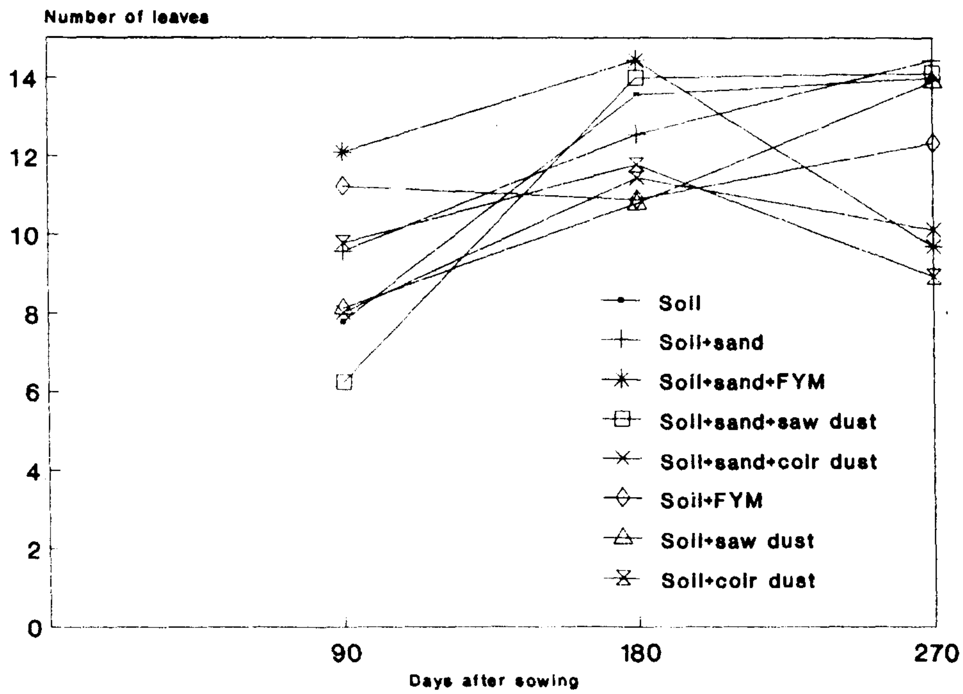


Fig.20. Effect of rooting media on the number of leaves

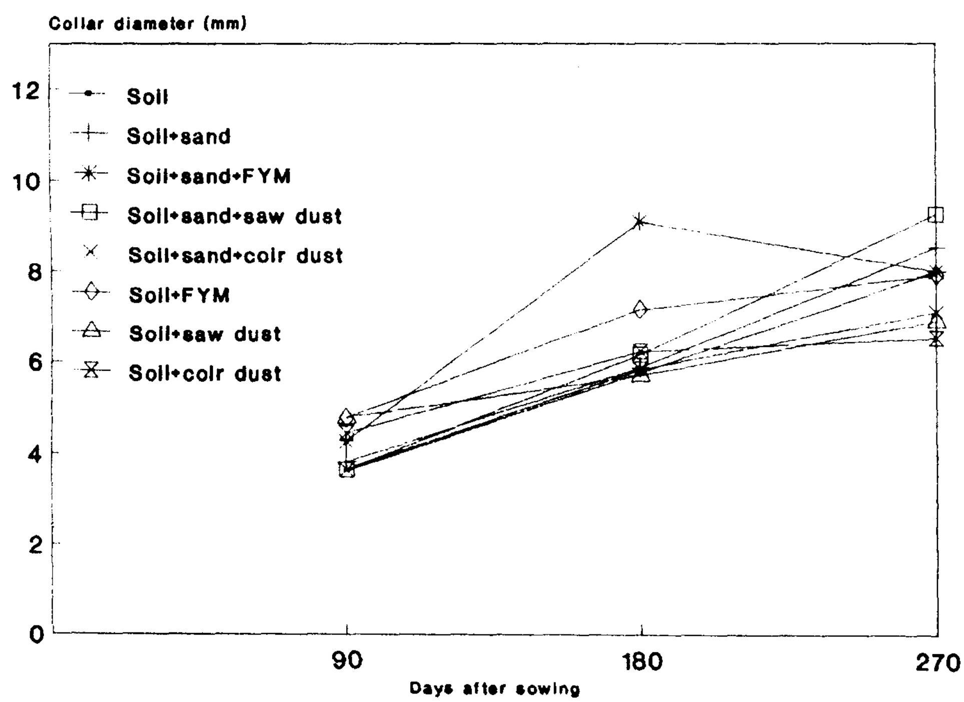


Fig.21. Effect of rooting media on the collar diameter

in the ratio of 2/3 and 1/3 each, soil and saw dust in the ratio of 2/3 and 1/3 each and soil and coir dust in the ratio of 2/3 and 1/3 each, compared to the control. The differences among these different rooting media were on par. The remaining three rooting media treatments did not have any influence on the collar diameter.

At 180 DAS, largest increase in the collar diameter (57%) was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 each also increased the collar diameter by 25 per cent. The other treatments did not have any influence.

At 270 DAS, no significant difference in the collar diameter was observed due to any of the rooting media treatments.

5.1.5 Shoot dry weight

Data pertaining to the influence different rooting media on the shoot dry weight of mahogany are given in Table 9. Significant increase in the shoot dry weight was observed at 90 DAS due to soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 each. The other treatments did not have any influence.

At 180 DAS, shoot dry weight increased by about 3 times in soil, sand and FYM in the proportion of 1/3 each compared to the control. The rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each increased the shoot dry weight of Mahogany by 137 per cent compared to the control. Shoot dry weight was not significantly increased by the rest of rooting media treatments.

Soil, sand and saw dust recorded the highest mean value at 270 DAS.

5.1.6 Root dry weight

At 90 DAS, root dry weight was not significantly influenced by any of the rooting media treatments.

At 180 DAS, largest root dry weight was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each. Soil and FYM in the proportion of 2/3 and 1/3 each significantly increased the root dry weight compared to the control. The root dry weight was not significantly influenced by rest of the rooting media treatments. At 270 DAS soil, sand and saw dust recorded the highest value (Table 9).

5.1.7 Leaf dry weight

At 90 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each gave rise to 139 per cent increase in the leaf dry weight compared to the control. Soil and FYM in the proportion of 2/3 and 1/3 each also gave rise to 130 per cent increase in leaf dry weight. The remaining treatments did not have any influence on leaf dry weight. At 180 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each gave rise to 167 per cent leaf dry weight compared to control. Soil and FYM in the ratio of 2/3 and 1/3 each also increased the leaf dry weight by 104 per cent. Rest of the rooting media did not have any influence on leaf dry weight of mahogany.

AT 270 DAS, significant differences in leaf dry weight were observed. However, the differences were erratic.

Table 9 Growth characters of mahogany seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight(g)			Root dry weight(g)			Leaf dry weight(g)			Root:shoot ratio	
	90	180	270	90	180	270	90	180	270	180	270
	(Days after sowing)										
Soil alone	0.47	2.42	9.12	0.22	0.79	2.87	0.86	3.67	6.09	0.34	0.36
Soil + sand	0.54	2.84	10.01	0.22	0.77	3.38	0.86	4.60	8.09	0.33	0.29
Soil+sand+FYM	0.99	10.28	11.67	0.23	1.98	3.03	2.06	10.13	7.12	0.21	0.23
Soil+sand+saw dust	0.46	2.60	12.67	0.15	0.67	4.50	0.52	3.66	10.78	0.30	0.32
Soil+sand+coir dust	0.46	3.54	6.91	0.18	0.78	2.40	0.76	4.45	6.13	0.28	0.28
Soil + FYM	0.92	5.74	10.43	0.24	1.59	3.07	1.98	7.50	8.22	0.25	0.22
Soil + saw dust	0.61	2.72	5.48	0.28	0.93	1.97	1.13	4.16	3.82	0.26	0.37
Soil + coir dust	0.58	3.10	5.62	0.21	0.95	1.56	1.18	4.25	3.90	0.29	0.30
SEm±	0.086	1.164	1.913	0.028	0.238	0.629	0.199	1.076	1.364	0.024	0.026
CD(0.05)	0.237	3.223	5.299	NS	0.659	1.742	0.551	2.980	3.780	0.065	0.072

5.1.8 Root : shoot ratio

At 180 DAS, root : shoot ratio of mahogany was significantly influenced by the different rooting media treatments (Table 9). Soil, sand and FYM in the ratio of 2/3 and 1/3 each significantly reduced the root : shoot ratio. Significant reduction was observed in the case of soil and saw dust in the ratio of 2/3 and 1/3 each. Largest reduction was in the case of soil, sand and FYM in the proportion of 1/3 each. Rest of the rooting media treatment were not effective.

At 270 DAS, root : shoot ratio was significantly influenced by the different rooting media treatments. Soil, sand and FYM in the proportion of 1/3 each and soil and FYM in the ratio of 2/3 and 1/3 significantly reduced the root : shoot ratio compared to the control.

5.2 Soil chemical characteristics

5.2.1 pH and EC

The influence of rooting media on soil pH and EC were insignificant in this species (Table 10).

5.2.2 Organic carbon

The highest percentage of organic carbon was noticed in the rooting media containing Soil (2/3) : saw dust (1/3) followed by soil (1/3) + FYM (1/3) and soil (1/3) + coir dust (1/3). Soil + sand + FYM (1/3) each registered the lowest percentage of organic carbon.

Table 10. Soil chemical properties (0-15 cm soil layer) under *Swietenea macrophylla* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.2	0.063	0.743	6.12	216.67	0.138	0.052	0.525
Soil + sand	4.9	0.056	0.762	10.88	279.17	0.134	0.056	0.725
Soil+sand+FYM	4.7	0.073	0.552	42.50	266.67	0.106	0.087	0.625
Soil+sand+saw dust	4.6	0.086	0.0543	5.78	150.00	0.109	0.048	0.350
Soil+sand+coir dust	4.6	0.100	0.876	7.82	154.17	0.151	0.050	0.375
Soil 2/3 : FYM 1/3	4.5	0.067	1.076	40.80	187.50	0.189	0.084	0.375
Soil 2/3 : saw dust 1/3	4.6	0.084	1.305	5.44	87.50	0.266	0.032	0.325
Soil 2/3 : coir dust 1/3	4.8	0.074	1.019	6.46	125.00	0.192	0.042	0.400
SEm±	0.1651	0.0735	0.0534	0.4031	19.488	0.010	0.0002	0.0051
CD(0.05)	NS	NS	0.1618	1.221	59.05	0.033	0.0006	0.015

5.2.3 Nitrogen

With regard to N content almost a similar trend as in the case of organic carbon was noticed.

5.2.4 Phosphorus

Highest P content was found with the medium containing soil + sand + FYM (1/3) each and soil (2/3) + FYM (1/3). This was 7 times higher compared to control. The magnitude of the difference between other treatments were very narrow.

5.2.5 Potassium

Among the eight rooting media tried, soil + sand produced the highest K content followed by soil + sand + FYM and soil alone. The rooting media containing soil 1/3 : FYM (1/3) also produced significant effect on K. The rest of the treatments were insignificant in this aspect.

6 ***Tectona grandis***

6.1 Biometric observations

6.1.1 Shoot length

At 90 DAS, when the rooting medium of soil, sand and FYM in the proportion of 1/3 each increased the shoot length by about 3.6 times compared to control and the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 increased the shoot length by about five times. The other five rooting media did not have any significant influence (Fig. 22).

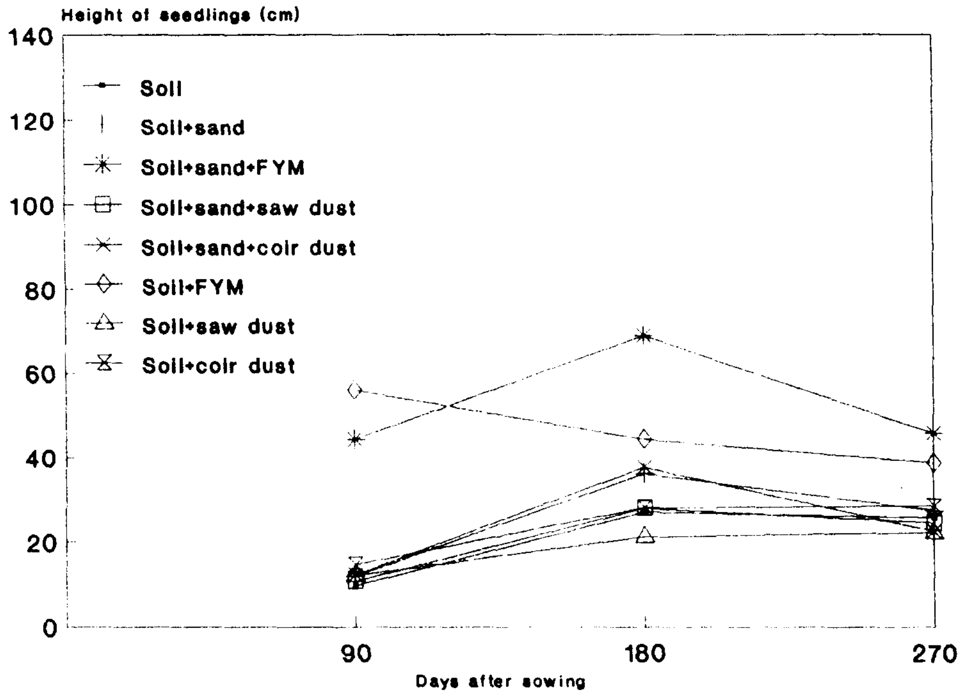


Fig.22. Effect of rooting media on the height of teak

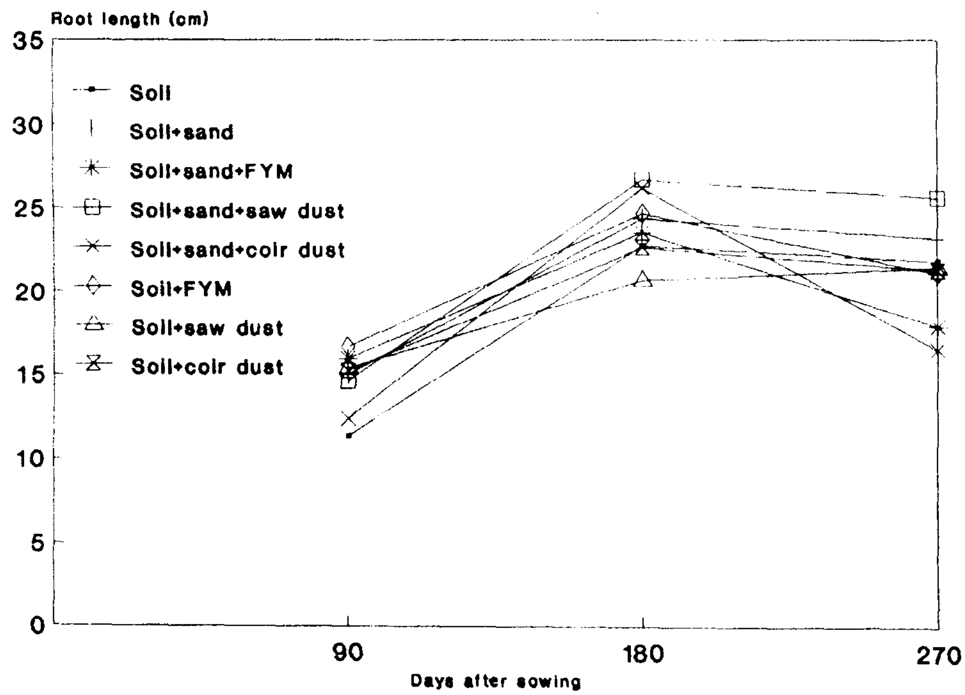


Fig.23. Effect of rooting media on the root length of teak

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to 154 per cent increase in the shoot length of teak compared to the control. The rooting media of soil and FYM in the ratio of 2/3 and 1/3 each resulted in 54 per cent increase in shoot length compared to the control. The remaining treatments did not have any influence.

At 270 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to largest increase in shoot length (78%) compared to the control. Soil and FYM in the ratio of 2/3 and 1/3 each significantly increased the shoot length by 51 per cent. The other five rooting media did not have any significant influence.

6.1.2 Root length

Data pertaining to the influence of different rooting media on the root length of Teak are given in Fig.23. The different rooting media did not have any influence on the root length of teak at any of the stages of observation.

6.1.3 Number of leaves

Rooting media significantly influenced the number of functional leaves of teak (Fig. 24). Surprisingly, a decrease in the number of functional leaves was observed at 90 DAS in the rooting media of soil, sand and FYM in the proportion of 1/3 each compared to the control. This may be either due to poor sampling or due to leaf shedding on account of its deciduous character.

At 180 DAS and 270 DAS, the number of leaves was not significantly affected by the different rooting media.

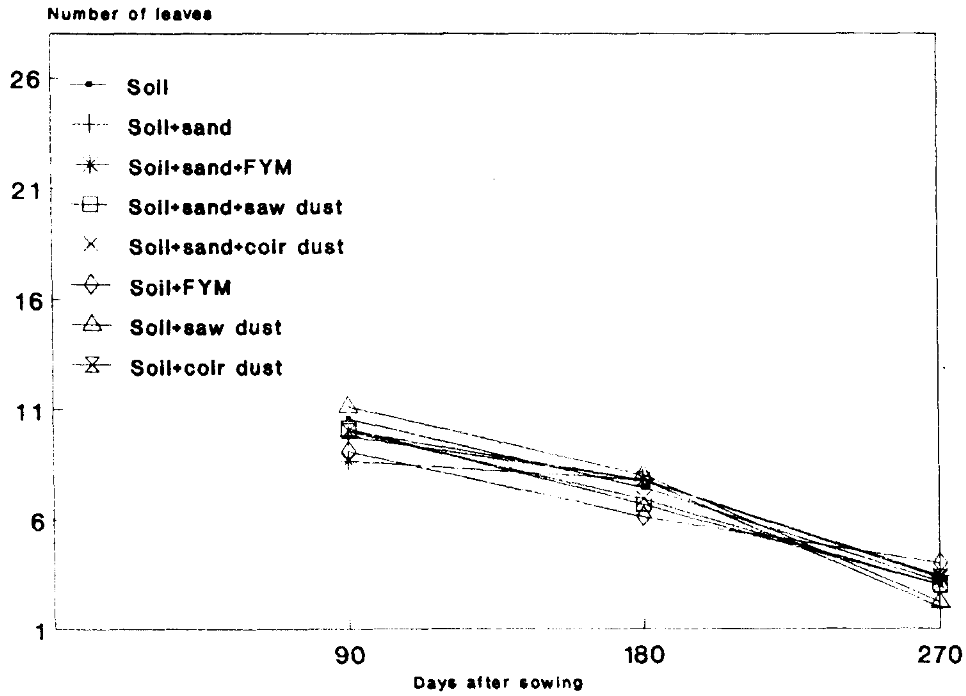


Fig.24. Effect of rooting media on the number of leaves

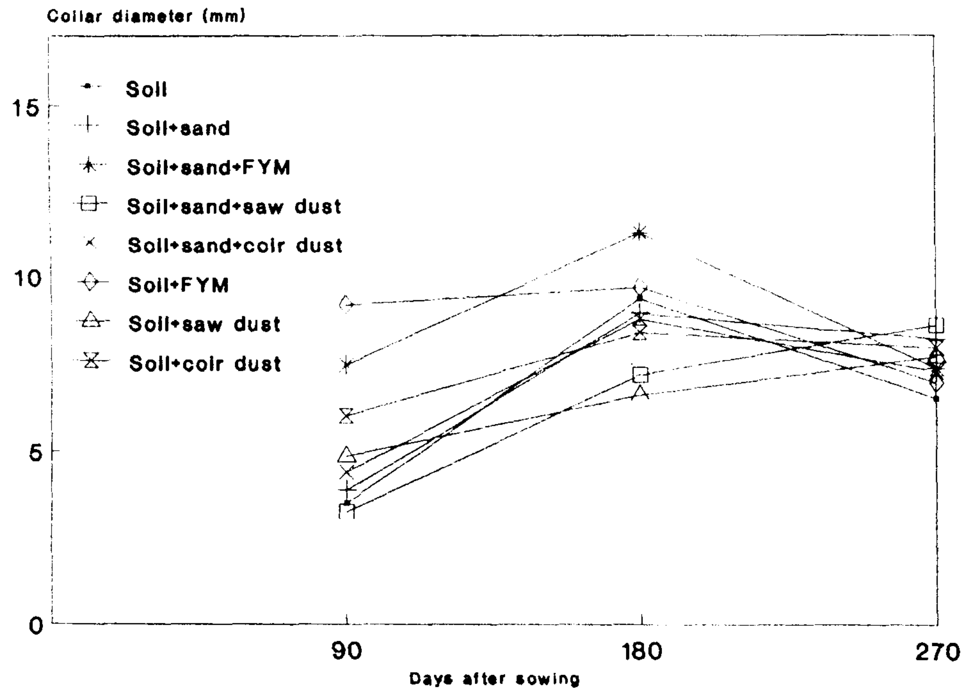


Fig.25. Effect of rooting media on the collar diameter

6.1.4 Collar diameter

At 90 DAS, highly significant response was obtained in the collar diameter of teak due to the effect of different rooting media (Fig. 24). Soil and FYM in the ratio of 2/3 and 1/3 each gave rise to 162 per cent increase compared to the control. The next best was the rooting medium of soil, sand and FYM in the proportion of 1/3 each which gave rise to 113 per cent increase. Soil and coir dust in the ratio of 2/3 and 1/3 each also increased the collar diameter significantly. The remaining treatments were not effective in increasing the collar diameter.

At 180 DAS, soil and saw dust in the ratio of 2/3 and 1/3 each significantly reduced the root collar diameter compared to the control. The other rooting media did not have any influence. At 270 DAS, the rooting media did not have any influence on the collar diameter of teak.

6.1.5 Shoot dry weight

Data pertaining to the influence of different rooting media on the shoot dry weight of teak are given in Table 11.

At 90 DAS, soil and FYM in the ratio of 2/3 and 1/3 each gave rise to twenty fold increase in the shoot dry weight of teak compared to the control. Soil, sand and FYM in the proportion of 1/3 each resulted in about 14 times increase in the shoot dry weight compared to the control. The remaining five rooting media did not have any significant influence on the shoot dry weight of teak.

At 180 DAS, soil, sand and FYM in the proportion of 1/3 each gave rise to about five times increase in the shoot dry weight of teak compared to the control.

Table 11 . Growth characters of Teak seedlings at different periods as affected by the rooting medium

Rooting medium	Shoot dry weight (g)			Root dry weight (g)			Leaf dry weight (g)			Root:shoot ratio
	90	180	270	90	180	270	90	180	270	270
	(Days after sowing)									
Soil alone	0.25	2.24	1.37	0.31	3.82	4.11	0.88	5.54	0.33	0.88
Soil+sand	0.28	3.56	1.79	0.36	5.21	4.97	0.70	7.03	0.49	0.91
Soil+sand+FYM	3.45	13.21	2.65	1.11	10.58	5.00	5.94	12.62	1.00	0.49
Soil+sand+saw dust	0.24	1.93	2.02	0.28	3.60	8.77	0.82	3.95	0.47	0.87
Soil+sand+coir dust	0.32	3.22	1.20	0.25	4.67	5.27	0.90	6.09	0.41	0.70
Soil + FYM	5.03	5.19	2.55	2.43	8.00	5.07	7.95	7.24	0.51	0.61
Soil + saw dust	0.26	1.75	2.86	0.55	3.87	5.77	1.12	4.28	0.72	1.07
Soil + coir dust	0.38	3.18	1.61	0.73	5.63	5.56	1.77	6.93	0.45	1.17
SEm±	0.481	2.165	0.414	0.275	1.719	1.211	0.717	2.291	0.201	0.106
CD (0.05)	1.332	5.999	1.147	0.761	4.761	3.354	1.988	6.346	0.556	0.293

The remaining six rooting media did not have any influence on the shoot dry weight of teak.

At 270 DAS, soil and saw dust in the ratio of 2/3 and 1/3 each resulted in 108 per cent increase in the shoot dry weight when compared to the control. Rooting medium of soil, sand and FYM in the proportion of 1/3 each also significantly increased the shoot dry weight. Soil, sand and coir dust in the proportion of 1/3 each also significantly increased the shoot dry weight. All the other four rooting media did not have any influence on the shoot dry weight of teak.

6.1.6 Root dry weight

At 90 DAS, the rooting medium of soil and FYM in the ratio of 2/3 and 1/3 each gave rise to about 7 times more root dry weight compared to the control (Table 11). Soil, sand and FYM in the proportion of 1/3 each gave rise to 258 per cent increase. The other rooting media did not have any significant influence. At 180 DAS soil, sand and FYM 1/3 each and at 270 DAS soil, sand and saw dust was found superior when compared to the control.

6.1.7 Leaf dry weight

At 90 DAS, the rooting medium of soil and FYM in the proportion of 2/3 and 1/3 each gave rise to the most significant increase in leaf dry weight resulting an increase of 8 times compared to the control (Table 11). The next best was soil, sand and FYM in the proportion of 1/3 each. The remaining five rooting media had no significant influence on the leaf dry weight of teak.

At 180 DAS and 270 DAS, soil, sand and FYM 1/3 each produced a significant effect on the leaf dry weight of teak.

6.1.8 Root : shoot ratio

Data pertaining to the influence of different rooting media on the root:shoot ratio of teak seedlings are given in Table 11. At 270 DAS, a highly significant reduction in the root:shoot ratio of teak was observed due to the rooting medium of soil, sand and FYM in the proportion of 1/3 each compared to the control. The rest of the treatments were not effective in influencing the root:shoot ratio of teak.

6.2 Soil chemical characteristics

6.2.1 pH and EC

The soil pH was not significantly influenced by any of the media. As regard to EC, the only media that showed a significant difference was soil + sand + coir dust (Table 12).

6.2.2 Organic carbon

Highest organic carbon content was shown by the rooting media containing soil + sand + FYM and soil 1/3 + FYM 1/3. Also soil 2/3 + coir dust 1/3 produced high organic carbon content compared to control. The lowest was noticed in soil + sand + saw dust.

Table 12. Soil chemical properties (0-15 cm soil layer) under *Tectona grandis* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.6	0.066	1.305	6.12	75.00	0.298	0.048	0.225
Soil + sand	4.7	0.089	1.143	6.80	129.17	0.266	0.052	0.300
Soil + sand + FYM	4.8	0.057	1.390	9.18	179.17	0.173	0.063	0.425
Soil + sand + saw dust	4.5	0.081	0.543	6.12	137.50	0.108	0.046	0.350
Soil + sand + coir dust	4.4	0.106	1.305	5.44	254.17	0.256	0.045	0.575
Soil + FYM	4.6	0.093	1.390	7.82	200.00	0.289	0.056	0.475
Soil + saw dust	4.5	0.102	1.124	5.10	108.33	0.212	0.042	0.350
Soil + coir dust	4.4	0.067	1.343	6.80	162.50	0.263	0.050	0.350
SEm±	0.1437	0.0157	0.0572	0.4005	22.788	0.011	0.0002	0.0102
CD(0.05)	NS	0.047	0.1733	1.213	69.05	0.035	0.0006	0.031

6.2.3 Nitrogen

Control (soil alone) recorded the highest N content. Soil + sand + saw dust registered the least N content followed by soil + sand + FYM.

6.2.4 Phosphorus

Significant increase in the concentration of both total and available P was observed due to the roating media of soil + sand + FYM and soil 2/3 and FYM 1/3. No other media was superior to control with respect to available P.

6.2.5 Potassium

Regarding K concentration, soil + sand + coir dust recorded the highest content followed by soil 2/3 + FYM 1/3. The superiority of other treatments were in the order soil + sand + FYM, soil 2/3 + coir dust 1/3 , soil + sand + saw dust, soil + sand, soil 2/3, saw dust 1/3 and soil alone.

7 ***Vateria indica***

7.1 Biometric observations

7.1.1 Shoot length

The height of vateria was not significantly affected by the different rooting media tried at 90 DAS and 180 DAS. But at 270 DAS, the rooting medium of soil and saw dust in the ratio of 2/3 and 1/3 drastically reduced the shoot length. Another rooting medium of soil and sand in the ratio of 2/3 and 1/3 each also resulted in reduction of shoot length by 312 per cent compared to the control. All the other rooting media did not have any influence on the height growth of vateria.

7.1.2 Root length

The root length of vateria was not significantly influenced by the different treatments at 90 DAS and 180 DAS. At 270 DAS, the rooting medium of soil and sand in the proportion of 2/3 and 1/3 each significantly reduced the root length by 207 per cent compared to control. All the remaining treatments have no significant influence on the root length of vateria.

7.1.3 Leaf number

The different rooting media did not significantly affect the number of functional leaves in vateria for the observation taken 180 DAS (Table 13). Soil 2/3 : FYM 1/3 and soil alone produced the maximum number of leaves at 90 and 270 DAS respectively.

7.1.4 Collar diameter

Data pertaining to the influence of different rooting media on the collar diameter of vateria are given to Table 13. At 90 DAS, collar diameter of vateria was not significantly affected by the different rooting media. Even though, significant differences were found in the collar diameter of vateria at 180 and 270 DAS due to the different treatments tried, the results were erratic.

7.1.5 Shoot dry weight

Soil 2/3 + FYM 1/3 and soil, sand, saw dust 1/3 each recorded highest mean values at 90 and 270 DAS respectively (Table 14).

Table 13. Growth characters of vateria seedlings at different periods as affected by the rooting medium

Rooting medium	No. of leaves			Collar diameter (mm)		
	90	180	270	90	180	270
	(Days after sowing)					
Soil alone	13.11	20.00	19.56	6.89	8.43	8.60
Soil + sand	13.67	21.11	16.22	7.47	9.59	6.49
Soil + sand + FYM	14.56	19.89	12.56	7.56	7.34	6.84
Soil + sand + saw dust	13.22	20.00	14.89	6.98	7.87	8.24
Soil + sand + coir dust	12.78	22.44	19.22	7.32	8.42	7.47
Soil + FYM	15.78	21.11	16.78	7.56	7.31	7.20
Soil + saw dust	11.33	19.11	13.00	6.44	7.63	6.79
Soil + coir dust	13.33	18.44	17.89	7.00	7.66	7.37
SEm±	0.984	1.408	1.884	0.388	0.472	0.514
CD (0.05)	2.725	NS	5.218	NS	1.308	1.423

At 180 DAS, the rooting media of soil and sand in the proportion of 2/3 and 1/3 each significantly increased the shoot dry weight by 92 per cent compared to control. All the remaining treatments did not influence the shoot dry weight in vateria.

7.1.6 Root dry weight

The different rooting media tried did not influence the root dry weight in vateria at 90 DAS, 180 DAS and 270 dAS (Table 14).

7.1.7 Leaf dry weight

Data pertaining to the influence of different roots media on the leaf dry weight of vateria are given in Table 14. At 90 DAS, 180 DAS and 270 DAS the different rooting media did not significantly affect the leaf dry weight of vateria.

7.1.8 Root : shoot ratio

Data pertaining to the influences of different rooting medium on the root:shoot ratio of vateria are given in Table 14. At 180 DAS, the different rooting media did not significantly influence the root:shoot ratio. At 270 DAS, root:shoot ratio of vateria was largest due to soil and saw dust in the ratio of 2/3 and 1/3 each. This was 50 per cent more compared to control. Rest of the rooting media treatments were not effective in influencing the root:shoot ratio of vateria.

7.2 Soil chemical characteristics

7.2.1 pH and EC

No significant difference was observed in the case of soil pH due to the

Table 14. Growth characters of Vateria seedlings at different dates as affected by the date of sowing

Rooting medium	Shoot dry weight (g)			Root dry weight (g)			Leaf dry weight (g)			Root:shoot ratio	
	90	180	270	90	180	270	90	180	270	180	270
	(Days after sowing)										
Soil alone	1.73	3.50	3.36	1.70	2.95	2.92	2.75	5.26	4.41	0.59	0.63
Soil + sand	2.40	6.72	2.84	2.15	4.21	3.02	3.33	7.00	3.17	0.57	0.68
Soil+ sand + FYM	2.28	3.62	2.71	1.85	3.31	2.47	3.22	5.51	3.33	0.73	0.59
Soil+sand+saw dust	1.40	4.30	5.71	1.57	2.88	4.36	2.54	5.99	5.97	0.69	0.62
Soil+sand+coir dust	2.00	4.81	3.90	1.88	3.24	3.28	3.08	6.83	5.47	0.50	0.68
Soil + FYM	2.89	3.53	3.72	1.88	3.31	3.00	3.58	5.42	5.20	0.50	0.53
Soil + saw dust	1.36	3.72	2.85	1.28	2.99	2.22	2.08	4.40	2.28	0.76	0.85
Soil + coir dust	1.58	3.23	4.08	1.65	3.38	3.14	2.91	4.54	5.24	0.79	0.56
SEm±	0.371	0.714	0.716	0.293	0.484	0.512	0.481	0.724	0.787	0.069	0.061
CD(0.05)	1.03	1.979	1.98	NS	NS	NS	NS	NS	2.180	0.192	0.161

different rooting media treatments. Soil + sand + FYM and soil 2/3 + FYM 1/3 produced significantly high value with respect to electrical conductivity than any other media (Table 15).

7.2.2 Organic carbon

Control (soil alone) recorded the highest percentage of organic carbon. The lowest content of organic carbon was found with soil + sand + FYM and soil + sand + saw dust.

7.2.3 Nitrogen

Regarding total N the highest content was shown by the rooting media having soil 2/3 + coir dust 1/3. N content of all other media were less than that of control. The lowest N content was registered by soil + sand + FYM followed by soil + sand + saw dust and soil 2/3 + FYM 1/3.

7.2.4 Phosphorus

P content of all the rooting media were found less when compared to the control. The lowest P content was exhibited by soil + sand and soil + sand + FYM.

7.2.5 Potassium

With respect to K, rooting media containing soil 2/3 + saw dust 1/3 recorded the highest concentration (183.33 ppm) followed by soil 2/3 + FYM 1/3 and soil + sand + saw dust. Soil + sand was the most inferior medium with respect to this.

Table 15. Soil chemical properties (0-15 cm soil layer) under *Vateria indica* seedlings at the end of the study period

Treatment	pH	EC (dSm^{-1})	OC (%)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
Soil alone	4.7	0.116	1.362	7.480	137.50	0.254	0.084	0.325
Soil + sand	4.6	0.126	0.981	2.720	70.83	0.192	0.042	0.250
Soil + sand + FYM	4.6	0.276	0.743	2.720	129.17	0.143	0.046	0.325
Soil + sand + saw dust	4.5	0.09	0.752	3.400	154.17	0.149	0.056	0.375
Soil + sand + coir dust	4.5	0.163	0.876	6.120	116.67	0.175	0.076	0.350
Soil + FYM	4.6	0.219	0.809	5.780	166.67	0.158	0.070	0.350
Soil + saw dust	5.0	0.086	1.257	3.280	183.33	0.246	0.054	0.400
Soil + coir dust	4.7	0.079	1.305	3.400	150.00	0.256	0.063	0.375
SEm±	0.1823	0.0293	0.0577	0.0392	25.068	0.011	0.0002	0.010
CD(0.05)	NS	0.088	0.175	0.119	75.96	0.034	0.0006	0.030

EXPERIMENT-II

In this experiment, the effect of four different rooting media on the growth behaviour of six forest tree seedlings is presented under four sections viz., biometric observations, tissue nutrient concentration, soil chemical characteristics and physiological parameters of seedlings.

1 *Albizia lebbeck*

Data pertaining to the effect of different media on the growth characteristics of Albizia are presented in Tables 16 and 17.

1.1 Biometric observations

1.1.1 Shoot length

The influence of the media on the shoot height was insignificant in this species throughout the growing period. However, the data shows that there is a trend of increase in shoot length in soil (1/3) : sand (1/3) : FYM (1/3) compared to the other treatments.

1.1.2 Root length

When the growth of seedlings was observer after 180 DAS, the seedlings showed significant differences due to treatment effect. At 270 DAS, seedlings grown in soil (1/3) : sand (1/3) : FYM (1/3) had the maximum root length of 36.2 cm while seedlings in soil (1/2) : sand (1/3) : neemcake (1/6) recorded the lowest root length of 25.5 cm.

1.1.3 Number of leaves

Treatment differences were found to be significant with regard to this parameter. At 90 DAS seedlings in soil (1/3) : sand (1/3) : FYM (1/3) produced the maximum number of leaves. The results obtained at 180 and 270 DAS were not significant.

1.1.4 Collar diameter

With regard to the collar diameter, it was found that there was no significant difference between the various treatments when observed at 180 DAS. At 270 DAS, soil (1/3) + sand (1/3) + FYM (1/3) was found superior to other treatments.

1.1.5 Shoot weight

There was no significant difference between the various treatments on shoot weight of *Albizia* at any of the growth stages observed.

1.1.6 Root weight

At 270 DAS, the influence of soil (1/3) : sand (1/3) : FYM (1/3) was significantly superior to the rest of the treatments in this regard.

1.1.7 Leaf weight

Leaf weight of Albizia was not significantly affected by rooting media at different growth stages. Highest leaf weight was recorded by soil (1/3) : sand (1/3) : FYM (1/3) at 270 DAS.

Table 16. Growth characters of *Albizia lebbeck* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)		No. of leaves $plant^{-1}$			Collar diameter (mm)	
	90	180	270	180	270	90	180	270	180	270
	(Days after sowing)									
T_1	10.6	24.2	30.3	21.6	36.2	5.2	12.4	6.1	3.6	5.4
T_2	10.5	27.8	27.7	28.3	28.6	5.1	7.5	5.6	4.2	4.8
T_3	9.8	29.9	22.7	28.8	25.5	4.6	10.8	4.7	3.9	4.4
T_4	9.9	25.2	22.4	33.2	26.6	4.0	9.1	5.1	3.8	4.5
SEm±	1.29	3.09	4.04	3.96	3.13	0.41	2.12	1.03	0.33	0.32
CD(0.05)	NS	NS	NS	11.5	9.13	1.19	NS	NS	NS	0.93

Table 17. Dry matter accumulation of *Albizia lebbeck* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot weight (g)		Root weight (g)		Leaf weight (g)		Root:shoot ratio	
	180	270	180	270	180	270	180	270
T_1	2.10	2.25	1.55	5.82	1.81	1.92	0.47	1.63
T_2	1.85	2.56	2.55	4.94	1.52	1.26	0.80	1.30
T_3	2.58	1.58	2.45	2.71	1.98	0.97	0.58	1.67
T_4	2.26	1.30	2.58	4.23	1.63	1.25	0.77	1.65
SEm±	0.54	0.64	0.37	0.88	0.29	0.29	0.10	0.42
CD(0.05)	NS	NS	NS	2.56	NS	0.84	0.29	NS

T_1 - Soil (1/3) + Sand (1/3) + FYM (1/3); T_3 - Soil (1/2) + Sand (1/3) + neemcake (1/6)

T_2 - Soil (1/2) + Sand (1/3) + FYM (1/6); T_4 - Soil (1/2) + Sand (1/2)

1.1.8 Root : shoot ratio

All the four different type of growing media produced similar effects on the root : shoot ratio of *Albizia*. No definite trend could be seen.

1.1.9 Population count

Data regarding the number of plants in different rooting media at different periods are presented in Table 18.

Maximum count was seen in soil (1/2) : sand (1/3) : neemcake (1/6) followed by soil (1/2) : sand (1/3) : FYM (1/6) at 90 DAS. The minimum number of plants was observed in the rooting medium of soil, sand and FYM (1/3) each. However, statistically the difference was not significant. At 180 DAS number of plants was significantly high in soil (1/2) : sand (1/2) followed by soil (1/2) : sand (1/3) : neemcake (1/6). Though statistically non-significant, similar trend was found at 270 DAS also.

1.2 Tissue nutrient concentration

Data pertaining to the effect of different rooting media on the nutrient content of *Albizia* seedlings are furnished in Tables 19 and 20.

1.2.1 Nitrogen

N concentration of the above ground portions showed substantial variability. In general, it decreased in the order soil (1/3) + sand (1/3) + FYM (1/3) > soil (1/2) + sand (1/3) + FYM (1/6) > soil (1/2) + sand (1/3) + neemcake (1/6) > soil (1/2) + sand (1/2) at 90 DAS.

Table 18. Effect of rooting media on population count

Days after sowing	Treatments	Albizia	Ceiba	Dalbergia	Hopea	Sandal	Teak
	T_1	237.33	298.33	297.67	200.00	103.67	371.67
	T_2	255.67	318.67	338.67	201.00	99.67	477.00
90	T_3	320.33	300.00	329.67	250.67	105.00	423.00
	T_4	247.67	264.00	293.33	224.00	117.67	465.67
	SEm±	51.26	19.50	24.90	14.23	11.27	55.02
	CD(0.05)	NS	NS	NS	49.26	NS	NS
	T_1	114.33	266.67	245.67	168.67	66.33	265.00
	T_2	182.33	247.00	245.00	137.33	89.67	318.67
180	T_3	202.33	276.67	262.00	162.00	59.33	278.67
	T_4	299.00	271.00	310.00	189.33	50.67	413.67
	SEm±	22.92	9.72	15.92	17.10	9.45	23.10
	CD(0.05)	79.30	NS	55.11	NS	32.70	79.95
	T_1	112.33	208.00	245.00	154.00	57.33	183.67
	T_2	162.66	219.00	242.67	114.33	77.33	233.33
270	T_3	205.00	236.33	222.00	152.67	58.00	226.33
	T_4	222.00	192.33	273.33	167.66	45.30	350.00
	SEm±	34.53	18.32	17.42	20.46	9.59	16.61
	CD(0.05)	NS	NS	NS	NS	NS	57.48

Observations recorded after 180 days showed that soil 1/3 + sand 1/3 + FYM 1/3 was on par with soil 1/2 + sand 1/3 + FYM 1/6 and soil 1/2 + sand 1/3 + neemcake 1/6 and was significantly superior to soil 1/2 + sand 1/2.

Soil 1/2 + sand 1/2 registered the lowest N content at 270 days after planting. At this stage soil 1/2 + sand 1/3 + neemcake 1/6 was significantly superior to other treatments.

As regards to root N content, soil 1/3 + sand 1/3 + FYM 1/3 had the highest N (3.08%) followed by soil 1/2 + sand 1/3 + FYM 1/6 (2.8%), while soil 1/2 + sand 1/2 had the lowest (2.06%).

1.2.2 Phosphorus

A highly significant variability was observed at 90, 180 and 270 DAS among the rooting media with respect to P content. Soil (1/3) : sand (1/3) : FYM (1/3) consistently recorded high P content throughout the growth stages. It was closely followed by soil (1/2) : sand (1/3) : FYM (1/6). The medium that gave the lowest percentage was soil 1/2 : sand 1/2.

Among the treatments soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : FYM 1/6 registered significantly higher value for root P content. They were on par throughout the growth stages. Soil 1/2 : sand 1/2 was the most inferior medium with respect to P content.

1.2.3 Potassium

The concentration of K in different rooting media showed marked

Table 19. Tissue nutrient concentration (%) of *Albizia lebbeck* seedlings

Days after sowing	Treat-ment	Shoot			Root		
		N	P	K	N	P	K
90	T_1	2.940	0.073	0.553	2.660	0.053	0.460
	T_2	2.660	0.067	0.453	2.240	0.046	0.320
	T_3	2.427	0.053	0.453	1.867	0.050	0.317
	T_4	2.053	0.043	0.353	1.867	0.030	0.277
	SEm±	0.0301	0.0017	0.0149	0.0971	0.0025	0.0136
	CD(0.05)	0.104	0.0057	0.051	0.336	0.0086	0.046
180	T_1	3.531	0.084	0.599	3.080	0.080	0.443
	T_2	3.484	0.087	0.446	3.407	0.080	0.343
	T_3	3.640	0.061	0.524	1.820	0.060	0.380
	T_4	2.987	0.044	0.413	2.333	0.040	0.350
	SEm±	0.1054	0.0023	0.0156	0.2185	0.0003	0.0274
	CD(0.05)	0.3075	0.0067	0.0455	0.7560	0.0000	0.0948
270	T_1	3.173	0.090	0.699	3.080	0.073	0.703
	T_2	3.142	0.087	0.431	2.753	0.067	0.467
	T_3	3.500	0.062	0.471	3.380	0.050	0.403
	T_4	3.111	0.050	0.427	2.007	0.030	0.327
	SEm±	0.1051	0.0014	0.0146	0.0981	0.0022	0.0164
	CD(0.05)	0.3069	0.0041	0.0426	0.3394	0.0076	0.0567

Table 20. Nutrient uptake by *Albizia lebbeck* seedlings at different stages

Days after sowing	Treatment	N uptake (mg g^{-1})			P uptake (mg g^{-1})			K uptake (mg g^{-1})		
		Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total
	T_1	138.06	147.74	92.95	3.55	1.24	2.40	23.42	6.87	15.14
	T_2	117.41	86.87	102.25	2.94	2.04	2.50	15.03	8.75	11.91
180	T_3	165.98	44.59	105.09	2.83	1.54	2.19	23.89	9.31	16.54
	T_4	116.19	60.11	88.40	1.69	1.03	1.36	16.06	9.03	12.59
SEm±		0.591	1.301	0.841	0.614	0.334	0.306	0.973	0.529	0.699
CD (0.05)		2.044	4.501	2.910	NS	NS	1.059	3.365	1.829	2.418
	T_1	132.31	179.25	155.89	3.75	4.25	3.52	29.15	40.91	35.05
	T_2	120.02	136.00	128.07	3.32	3.31	3.33	16.46	23.07	19.76
270	T_3	89.25	91.59	90.49	1.58	1.35	1.48	12.01	10.92	11.48
	T_4	79.33	84.89	82.24	1.27	1.27	1.28	10.89	13.83	12.36
SEm±		1.041	1.015	0.449	0.237	0.443	0.273	0.287	0.016	0.147
CD(0.05)		3.60	3.512	1.553	0.822	1.535	0.944	0.994	0.055	0.509

variability. Unlike in the case of N and P, concentration of K in the above ground portions followed the order. Soil 1/3 : sand 1/3 : FYM 1/3 > soil 1/3 : sand 1/3 : neemcake 1/6 > soil 1/2 : sand 1/3 : FYM 1/6 > soil 1/2 : sand 1/2.

Regarding content of root K, the medium that produced a significant effect was soil 1/3 : sand 1/3 : FYM 1/3. Other treatments had no significant influence at 90 and 180 DAS, and they were on par. However, at 270 DAS, soil 1/2 : sand 1/3 : FYM 1/3 was found to be superior to soil 1/2 : sand 1/3 : neemcake 1/6.

1.3 Soil chemical characteristics

The physico-chemical properties of the soil under Albizia seedlings tested showed significant variations ($P < 0.05$) at different stages of growth (Table 21).

1.3.1 Soil pH

The pH values did not show any marked variation during any period of seedling growth. However, it appeared that pH registered lower values in the treatment soil than the non cropped field soils.

1.3.2 Electrical conductivity

The electrical conductivity of the rooting medium of soil, sand and FYM in the proportion of 1/3 each was significantly higher than the rest of the rooting medium treatments.

1.3.3 Organic carbon

At 90 DAS, soil organic carbon status of soil 1/2 : sand 1/2 was

Table 21. Soil chemical properties (0-15 cm soil layer) under *Albizia lebbeck* seedlings

Days after sowing	Treatment	pH	EC (dSm^{-1})	OC (%)	Available N ($kg\ ha^{-1}$)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	3.8	0.227	2.167	445.31	17.91	116.67	0.429	0.09	0.41
	T_2	4.9	0.079	1.500	407.68	7.59	100.00	0.364	0.07	0.35
90	T_3	4.6	0.070	1.867	464.12	13.26	112.50	0.495	0.10	0.46
	T_4	4.6	0.045	2.267	388.86	7.25	125.00	0.476	0.09	0.38
	SEm±	0.1524	0.0435	0.2034	21.951	0.844	22.341	0.0384	0.0027	0.0242
	CD(0.05)	NS	0.1505	0.7037	NS	2.919	NS	NS	0.0093	0.084
	T_1	4.3	0.239	2.461	426.49	17.79	112.50	0.4854	0.110	0.377
	T_2	4.6	0.083	2.530	397.23	7.93	116.67	0.4294	0.097	0.343
180	T_3	4.4	0.084	1.853	432.76	12.47	158.33	0.4854	0.103	0.400
	T_4	4.2	0.109	2.627	388.86	6.69	87.50	0.4014	0.107	0.403
	SEm±	0.1500	0.0114	0.1408	15.611	1.304	10.135	0.030	0.0027	0.0190
	CD(0.05)	NS	0.039	0.487	NS	4.51	35.08	0.058	0.0093	NS
	T_1	4.6	0.231	2.274	355.41	26.52	129.16	0.5786	0.13	0.42
	T_2	4.7	0.043	2.196	411.86	11.10	166.66	0.4666	0.10	0.36
270	T_3	4.5	0.153	1.696	355.41	5.32	250.00	0.5506	0.10	0.37
	T_4	4.5	0.101	2.785	416.04	5.44	79.16	0.392	0.11	0.37
	SEm±	0.2132	0.04	0.0478	10.91	1.79	12.50	0.0313	0.0022	0.0173
	CD(0.05)	NS	0.146	0.1654	37.75	6.22	43.25	0.1082	0.0076	0.059

significantly higher (2.26%) than the rest. The lowest organic carbon was recorded by soil 1/2 : sand 1/3 : FYM 1/6 (1.5%). At 180 DAS, soil 1/2 : sand 1/3 : neem-cake 1/6 registered the lowest organic carbon content while all other treatments were statistically superior and were on par. After 270 days of planting, the soil organic carbon percentage of soil 1/2 : sand 1/2 was significantly higher (2.78%) than the rest.

1.3.4 Nitrogen

Different rooting media did not produce any significant influence on the percentage of total N at 90 DAS. After 180 DAS, soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 registered significantly higher values than the rest of the treatments. Exactly a similar trend was observed at 270 DAS also. In the case of available N, soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/2: sand 1/2 were significantly superior to soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 at 270 DAS.

1.3.5 Phosphorus

The highest concentration of both total and available P was observed in soil 1/3 : sand 1/3 :FYM 1/3 followed by soil 1/2 : sand 1/3 : neemcake 1/6.

1.3.6 Potassium

A significantly higher soil K content was recorded by soil 1/2 : sand 1/3 : neemcake 1/6 while all other treatments had a lower level of K despite being statistically on par.

1.4 Physiological parameters

1.4.1 Relative water content

The observatiosn on the effect of various treatments on the relative water content (RWC) of the seedlings are presented in Table 22.

Albizia seedlings showed significant differences due to treatments. The highest RWC was recorded with plants grown in soil (1/3) : sand (1/3) :FYM (1/3). The minimum RWC was characterised by plants grown in soil (1/2) : sand (1/2). Soil (1/2) : sand (1/3) : FYM (1/6) and soil (1/2) : sand (1/3) + neemcake (1/6) were intermediate and statistically on par.

1.4.2 Specific leaf area

The data related to specific leaf area are presented in Table 23.

Specific leaf area showed significant variation among treatments. Soil (1/3) : sand (1/3) : FYM (1/3) registered the highest leaf area (173.52 cm^2 g^{-1}) followed by soil (1/2) : sand (1/3) : FYM (1/6) (111.81 cm^2 g^{-1}). The soil (1/2) : sand (1/2) registered the lowest specific leaf area of 85.77 cm^2 g^{-1}.

1.4.3 Chlorophyll content

The chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents in seedlings grown in different rooting media are presented in Table 24.

The chlorophyll content of leaves was not significantly influenced by the rooting media. However, the highest content of chlorophyll 'a' and total chlorophyll were recorded by plants grown in soil (1/2) : sand (1/3) : FYM (1/6) .

Table 22. Relative water content (%) of seedlings as affected by different rooting media

Treatment	Albizia	Ceiba	Dalbergia	Hopea	Sandal	Teak
T_1	88.98	91.18	90.78	91.88	87.14	74.98
T_2	81.94	77.67	92.36	92.69	84.42	73.50
T_3	81.14	74.01	90.56	88.70	81.48	79.76
T_4	76.36	76.45	80.26	85.98	83.14	76.71
SEm ±	0.987	1.97	1.47	1.7831	0.5225	0.8519
CD(0.05)	3.41	6.81	5.11	6.17	1.81	2.95

Table 23. Sepcific leaf area ($cm^2 g^{-1}$) of seedlings affected by different rooting media

Treatment	Albizia	Ceiba	Dalbergia	Hopea	Sandal	Teak
T_1	173.517	184.123	192.830	122.927	133.363	168.290
T_2	111.807	199.150	130.130	152.133	262.287	143.980
T_3	90.667	172.067	97.967	162.620	164.410	119.933
T_4	85.770	165.597	109.693	157.513	153.470	155.327
SEm ±	1.9847	4.2851	6.7655	3.6925	6.1264	8.6349
CD(0.05)	6.87	14.82	23.39	12.76	21.17	29.88

Table 24. Effect of rooting media on the chlorophyll content (mg g^{-1}) of leaf tissue of seedlings

	Treat-ments	Albizia	Ceiba	Dalbergia	Hopea	Sandal
Chlorophyll 'a'	T_1	0.536	0.351	0.508	0.372	0.533
(mg g^{-1})	T_2	1.503	0.766	0.579	0.436	0.883
	T_3	1.211	0.670	0.671	0.410	0.473
	T_4	0.643	0.543	0.654	0.422	1.071
	SEm±	0.3258	0.1230	0.1651	0.1062	0.1495
	CD(0.05)	NS	NS	NS	NS	0.517
Chlorophyll 'b'	T_1	1.806	0.535	0.841	0.951	0.665
(mg g^{-1})	T_2	1.132	0.533	0.813	0.927	0.558
	T_3	1.196	1.033	0.871	1.008	0.648
	T_4	1.993	0.381	1.319	0.931	0.644
	SEm±	0.2743	0.2190	0.3929	0.1936	0.1076
	CD(0.05)	NS	NS	NS	NS	NS
Total chlorophyll	T_1	2.343	0.886	1.349	1.354	1.198
(mg g^{-1})	T_2	2.636	1.299	1.392	1.366	1.441
	T_3	2.406	1.702	1.541	1.417	1.121
	T_4	2.630	0.923	1.972	1.323	1.714
	SEm±	0.3962	0.2316	0.4995	0.4583	0.2223
	CD(0.05)	NS	0.801	NS	NS	NS

2 *Ceiba pentandra*

There was marked variation in the growth rates of Ceiba seedlings due to different rooting media. The results obtained as shown in Tables 25 and 26.

2.1 Biometric observations

2.1.1 Shoot height

Shoot height of *Ceiba* was significantly affected by rooting media at different stages of growth. At 90 DAS, largest shoot height was produced by the rooting medium of soil 1/3 : sand 1/3. Shoot height due in the rooting medium of soil (1/2) : sand (1/3) : neemcake (1/6) and soil (1/2 : sand (1/3 : FYM (1/6) were on par. However, they were significantly inferior to the rooting medium of soil (1/3) : sand (1/3) : FYM (1/3). The same trend was maintained throughout the growth stages. Soil (1/2) : sand (1/2) produced the shortest shoots.

2.1.2 Root length

In this species, the media could significantly influence the length of the root at 90 DAS only. The longest roots were observed in the medium containing soil, sand and FYM in 1:1:1 ratio.

2.1.3 Number of leaves

With regard to the number of leaves, data recorded after 90 days showed that soil 1/3 : sand 1/3 : FYM 1/3 produced 11.6 leaves which was the highest and soil 1/2 sand 1/2 produced 8.0 leaves which was the lowest. Similar trend existed at 180 and 270 DAS also.

2.1.4 Collar diameter

The influence of rooting media on root collar diameter was significant at different stages of growth. Soil 1/3 : sand 1/3 : FYM 1/3 consistently registered a higher value for collar diameter growth at all stages of experimental period. Soil 1/2: sand 1/3 : FYM 1/6 was on par with soil 1/3 : sand 1/3 : FYM 1/3.

2.1.5 Shoot weight

Shoot weight of *Ceiba* was significantly influenced by rooting medium at different stages of growth. An eight fold increase was noted in the case of rooting medium of soil (1/3) : sand (1/3) : FYM (1/3) compared to the control. Soil (1/2) : sand (1/3) : FYM (1/6) was also significantly superior to the control. More or less same trend was maintained up to 270 DAS.

2.1.6 Root weight

From the data it is clear that root dry weight was significantly influenced by the rooting media treatments at all stages of observation. The seedlings grown in soil (1/3) : sand (1/3) : FYM (1/3) recorded the highest root weights while that in soil (1/2) : sand (1/2) consistently registered the minimum. The rest of the treatments were in the order, soil (1/2) : sand (1/2) : FYM (1/6) > soil (1/2) : sand (1/3) : neemcake (1.6).

2.1.7 Leaf weight

Leaf weight in the rooting media of soil, sand and FYM in the proportion of 1/3 each and soil, sand and FYM in the proportion of 1/2, 1/3 and 1/6 were

Table 25. Growth characters of *Ceiba pentandra* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)			No. of leaves			Collar diameter (mm)		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	55.4	93.4	115.5	19.1	33.0	29.4	11.6	16.2	8.5	8.1	13.2	15.2
T_2	41.5	83.7	97.0	17.5	29.3	29.6	10.4	12.8	10.7	7.1	11.3	14.7
T_3	36.2	74.6	96.6	12.3	26.0	29.3	9.4	11.6	9.0	5.5	10.7	14.8
T_4	15.4	36.1	39.5	10.3	27.0	24.3	8.0	11.2	5.5	3.6	8.4	11.4
SEm ±	3.47	6.73	6.58	1.81	2.93	2.41	0.84	2.21	1.44	0.59	1.00	0.96
CD (0.05)	10.20	19.60	19.20	5.29	NS	NS	2.45	NS	4.2	1.72	2.94	2.81

Table 26. Dry matter accumulation of *Ceiba pentandra* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot weight (g)			Root weight (g)			Leaf weight (g)			Root:shoot ratio		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	2.00	17.50	25.54	0.76	6.02	8.67	2.82	5.30	3.13	0.15	0.26	0.29
T_2	1.56	9.63	19.70	0.71	3.52	7.96	2.30	4.40	3.58	0.18	0.24	0.32
T_3	0.63	9.69	16.65	0.48	3.34	9.59	1.23	3.97	3.65	0.28	0.24	0.51
T_4	0.25	4.37	7.07	0.20	2.45	3.54	0.54	2.31	0.89	0.25	0.36	0.45
SEm ±	0.32	2.49	3.07	0.16	0.95	1.70	0.32	0.85	0.64	0.06	0.02	0.10
CD (0.05)	0.93	7.29	8.96	0.46	2.77	4.96	0.94	2.48	1.85	NS	0.06	NS

T_1 - Soil (1/3) + Sand (1/3) + FYM (1/3) T_3 - Soil (1/2) + Sand (1/3) + neemcake (1/6)

T_2 - Soil (1/2) + Sand (1/3) + FYM (1/6) T_4 - Soil (1/2) + Sand (1/2)

on par and significantly superior to the control at 90 DAS and at 270 DAS. At 180 DAS soil (1/3) : sand (1/3) : FYM (1/3) was significantly superior to the rest of the treatments.

2.1.8 Root : shoot ratio

The data pertaining to this parameter are furnished in Table 26. There was no significant difference between different treatments at various growth stages.

2.1.9 Population count

The influence of the media on the population count of *Ceiba* was not significant. However, soil (1/2) : sand (1/3) : neemcake (1/6) registered the maximum count at all stages of observation (see Table 18).

2.2 Tissue nutrient concentration

2.2.1 Nitrogen

Significant difference could be observed among the treatments. The highest N content was recorded by soil 1/3 : sand 1/3 : FYM 1/3 after 90 days. At this stage soil 1/2: sand 1/3 : FYM 1/6 was found to be on par with soil 1/2 : sand 1/3 : neemcake 1/6. Soil 1/2 : sand 1/2 produced the lowest N concentration. The only medium that could significantly influence the N content at 180 and 270 DAS was soil 1/3 : sand 1/3 :FYM 1/3. All other treatments were inferior and were on par with respect to nitrogen content (Table 27).

Among the treatments soil 1/3 : sand 1/3 : FYM 1/3 produced significantly higher values in root N after three and six months of planting. After nine months the effect of medium was insignificant.

2.2.2 Phosphorus

With regard to the P content after 90 DAS soil 1/3 : sand 1/3: FYM 1/3 was significantly superior to all other treatments. Soil 1/3 : sand 1/3 : FYM 1/6 was on par with this at the other two stages. Soil 1/2: sand 1/2 invariably registered the lowest P content throughout the experiment.

Regarding P content in the root, the medium, soil 1/3 : sand 1/3 : FYM 1/3 produced the highest content. This treatment was on par with soil 1/2 : sand 1/3 : FYM 1/6 during at all stages of observation. The other two rooting media had no significant influence on root P content.

2.2.3 Potassium

K content also showed considerable variation in response to different rooting media. Observations recorded after 90 DAS revealed that soil 1/3 : sand 1/3 : FYM 1/3 was significantly superior to all other treatments. At 180 and 270 days after planting also, soil 1/3 : sand 1/3 : FYM 1/3 proved to be the best medium with respect to K. The next best treatment was soil 1/2 : sand 1/3 : neemcake 1/6. The highest root K was recorded by soil 1/2 : sand 1/3 : neemcake 1/6 and soil 1/3 : sand 1/3 : FYM 1/3 at 90 DAS. Soil 1/2 : sand 1/3 : neemcake 1/6 and soil 1/2 : sand 1/3 : FYM 1/6 were on par at 180 DAS and at 270 DAS. Soil 1/3 : sand 1/3 : FYM 1/3 followed by soil 1/2 : sand 1/3 : FYM 1/6 recorded the highest K content.

2.3 Soil chemical characteristics

Data pertaining to the influence of different rooting media on the soil chemical properties of Ceiba are given in Table 28.

Table 27. Tissue nutrient concentration (%) of *Ceiba pentandra* seedlings

Days after sowing	Treatment	Shoot			Root		
		N	P	K	N	P	K
90	T_1	2.193	0.120	1.177	1.680	0.040	0.583
	T_2	1.867	0.110	1.010	1.447	0.040	0.527
	T_3	1.727	0.100	1.050	1.540	0.043	0.593
	T_4	1.120	0.080	0.710	1.493	0.030	0.467
	SEm±	0.0602	0.0060	0.0195	0.0646	0.0017	0.0241
	CD(0.05)	0.0207	0.020	0.060	0.223	0.0057	0.0834
180	T_1	4.044	0.153	1.286	3.873	0.103	0.643
	T_2	3.282	0.144	0.972	3.453	0.103	0.800
	T_3	3.173	0.104	1.244	2.987	0.093	0.910
	T_4	3.173	0.092	0.833	2.847	0.090	0.360
	SEm±	0.0842	0.0028	0.0575	0.1622	0.0033	0.0375
	CD(0.05)	0.2457	0.0082	0.1678	0.5612	0.0114	0.1297
270	T_1	2.069	0.077	1.293	2.007	0.067	0.943
	T_2	1.913	0.072	0.696	2.333	0.070	0.550
	T_3	1.727	0.050	0.854	2.240	0.040	0.493
	T_4	1.789	0.036	0.454	2.193	0.040	0.370
	SEm±	0.0844	0.0021	0.0513	0.4012	0.0017	0.0143
	CD(0.05)	0.2463	0.0061	0.1497	NS	0.0059	0.0495

2.3.1 Soil pH

The effect of rooting media on soil pH did not differ among themselves. But it was observed that pH values decreased in all the treatments compared to the bare soil.

2.3.2 Electrical conductivity

The rooting medium of soil (1/2) : sand (1/3) and FYM (1/6) showed significant difference in the mean values of EC at 90 and 180 DAS. The remaining treatments did not produce any significant influence.

2.3.3 Organic carbon

Percentage of organic carbon was higher in soil 1/3 : sand 1/3 : FYM 1/3. The rest of the treatments had no significant influence on soil organic carbon at 90 DAS. At 180 DAS soil 1/2 : sand 1/3 : neemcake 1/6 registered highest percentage of organic carbon, closely followed by soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/2 which again was statistically significant compared to soil 1/2 : sand 1/3 : FYM 1/6. At 270 DAS soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : FYM 1/6 were highly significant than soil 1/2 : sand 1/3 : neemcake 1/6 which again was statistically superior to soil 1/2 : sand 1/2.

2.3.4 Nitrogen

Regarding total N content, soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 were on par and produced significantly higher values at 90 DAS. However at 180 DAS, all the media produced similar effects. At 270 DAS,

Table 28. Soil chemical properties (0-15 cm soil layer) under *Ceiba pentandra* seedlings

Days after sowing	Treat-ment	pH	EC (dSm^{-1})	OC (%)	Available N ($kg\ ha^{-1}$)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	4.5	0.096	2.900	436.95	6.35	95.83	0.523	0.083	0.393
	T_2	4.4	0.219	1.700	430.68	6.46	87.50	0.271	0.073	0.333
90	T_3	4.3	0.067	2.733	422.31	8.84	116.67	0.467	0.093	0.333
	T_4	4.3	0.072	2.400	474.58	15.30	70.83	0.541	0.100	0.327
	SEm±	0.1922	0.0250	0.3122	36.690	1.993	9.697	0.0352	0.0033	0.0230
	CD(0.05)	NS	0.0865	1.080	NS	6.88	33.53	0.1218	0.011	NS
	T_1	4.5	0.097	2.422	428.58	9.86	116.67	0.5134	0.110	0.360
	T_2	4.6	0.188	1.892	393.05	7.59	108.33	0.4106	0.103	0.337
180	T_3	4.5	0.105	2.785	411.86	9.41	212.50	0.4854	0.103	0.337
	T_4	4.4	0.126	2.225	416.04	12.47	70.83	0.392	0.107	0.383
	SEm±	0.1143	0.0157	0.0712	24.919	1.739	6.804	0.0360	0.0032	0.0123
	CD(0.05)	NS	0.054	0.246	NS	NS	23.54	NS	NS	0.042
	T_1	4.6	0.288	2.049	393.05	18.59	116.67	0.532	0.127	0.403
	T_2	4.9	0.090	2.029	365.87	11.79	116.67	0.4386	0.113	0.333
270	T_3	4.8	0.132	1.706	372.14	6.57	241.67	0.5414	0.113	0.360
	T_4	4.6	0.163	1.539	390.96	6.01	62.50	0.420	0.113	0.303
	SEm±	0.1561	0.0294	0.0475	20.828	0.833	20.09	0.0202	0.0033	0.0194
	CD(0.05)	NS	0.1017	0.164	NS	2.88	69.51	0.0696	0.011	0.067

Table 29. Nutrient uptake by *Ceiba pentandra* seedlings at different stages

Days after sowing	Treat-ment	N uptake ($mg\ g^{-1}$)			P uptake ($mg\ g^{-1}$)			K uptake ($mg\ g^{-1}$)		
		Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total
	T_1	105.70	12.77	59.23	5.78	0.30	3.04	56.73	4.43	30.08
	T_2	72.06	10.27	41.18	4.24	0.28	0.27	38.98	3.74	21.36
90	T_3	32.12	7.39	20.27	1.86	0.21	1.04	19.53	2.85	11.70
	T_4	8.85	2.98	5.91	0.63	0.06	0.34	5.61	0.93	3.26
SEm±		0.507	0.332	0.220	0.554	0.023	0.286	0.641	0.371	0.294
CD(0.05)		1.755	1.148	0.762	1.917	0.079	0.989	2.217	1.283	1.017
	T_1	922.03	233.15	577.98	34.88	6.20	20.52	293.21	38.71	166.06
	T_2	460.46	121.54	290.96	20.20	3.62	12.10	136.37	28.16	82.45
180	T_3	433.43	99.76	266.47	14.21	3.11	8.74	169.93	30.39	100.17
	T_4	211.95	69.75	140.69	6.14	2.20	4.21	55.64	8.82	32.14
SEm±		2.223	1.090	1.078	1.329	0.654	0.507	1.290	0.506	0.685
CD(0.05)		7.691	3.771	3.730	4.599	2.262	0.890	4.49	1.752	2.369
	T_1	593.18	174.00	383.59	22.07	5.81	13.94	370.70	81.75	226.23
	T_2	445.35	185.71	315.53	16.76	5.57	11.16	162.03	43.78	102.91
270	T_3	350.58	214.81	282.70	10.15	3.83	6.99	173.36	47.28	110.32
	T_4	142.40	77.63	110.01	2.86	1.41	2.13	36.14	13.09	24.61
SEm±		1.253	1.352	1.303	1.026	0.400	0.713	1.237	0.604	0.921
CD(0.05)		4.341	4.680	4.508	3.550	1.384	2.46	4.280	2.089	3.186

the trend was similar to that at 90 DAS. Available N was not significantly affected by the rooting media treatments. Soil (1/2) : sand (1/2) recorded high mean values.

2.3.5 Phosphorus

At 90 DAS both available and total P was significantly higher in soil 1/2 : sand 1/2. At 180 DAS none of the medium produced any significant effect on P content. At 270 DAS soil 1/3 : sand 1/3 : FYM 1/3 could exert a significant effect.

2.3.6 Potassium

Regarding available K in the surface layer (0-15 cm) the differences were statistically significant. The effect of soil 1/2 : sand 1/3 : neemcake 1/6 was significant at 90, 180 and 270 days after planting. At 180 DAS, the next best medium was soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : FYM 1/6. As regards to total K, the highest mean value was produced by soil 1/2 : sand 1/2 at 180 DAS but later replaced by soil 1/3 : sand 1/3 : FYM 1/3 at 270 DAS.

2.4 Physiological characteristics

2.4.1 Relative water content (RWC)

Among the four rooting media tried, only soil (1/3) : sand (1/3) : FYM (1/3) produced a significant effect on the RWC of seedlings (see Table 22). Soil (1/2) : sand (1/3) : FYM (1/6) recorded the second highest mean value.

2.4.2 Specific leaf area

Seedlings grown in soil (1/2) : sand (1/3) : FYM (1/6) registered the maximum specific leaf area and was significantly superior to others tested. The next best media with respect to leaf area was soil (1/3) : sand (1/3) : FYM (1/3). Rest of the treatments did not differ significantly with regard to this attribute (see Table 23).

2.4.3 Chlorophyll content

The total chlorophyll content of leaves was found to be significantly influenced by soil (1/2) : sand (1/3) : neemcake (1/6). Other treatments had no significant effect on the chlorophyll content of *Ceiba* seedlings (see Table 24).

3 ***Dalbergia latifolia***

The influence of different rooting media on the growth characters of Dalbergia at different stages of are given in Tables 30 and 31.

3.1 Biometric observations

3.1.1 Shoot height

Significant difference in shoot height was observed at 90, 180 and 270 days after planting. The shortest plants were observed with the medium containing soil 1/2 : sand 1/2. All the other rooting media significantly increased the shoot height and were on par among themselves.

3.1.2 Root length

In this species the media could significantly influence the length of the root at 270 DAS only. Soil, sand and FYM in the proportion of 1/3 each proved to be the best medium in increasing the length of roots. The rest of the treatments did not have any significant influence.

3.1.3 Number of leaves

With regard to the number of leaves, data recorded after 180 days showed that soil 1/2 : sand 1/3 : neemcake 1/3 produced 19.7 leaves which was the highest and soil 1/2 : sand 1/2 produced 9.5 leaves, which was the lowest. At 270 DAS soil (1/3) : sand (1/3) : FYM (1/3) was significantly superior to control.

3.1.4 Collar diameter

As regards to collar diameter all the other treatments were significantly superior to soil 1/2 : sand 1/2 at 90 DAS. Soil 1/2 : sand 1/3 : neemcake 1/6 was found to be superior at 180 and 270 DAS.

3.1.5 Shoot weight

Shoot weight was found to be significantly influenced by the various treatments. At 90 DAS soil (1/2) : sand (1/3) : FYM (1/6) was significantly superior to rest of the rooting media. At 180 DAS soil 1/2 : sand 1/3 : neemcake 1/6 was the best and during 270 DAS seedlings grown in soil 1/3 : sand 1/3 : FYM 1/3 recorded the highest shoot weight.

3.1.6 Root weight

Soil 1/2 : sand 1/3 : FYM 1/6 produced significant effect at 90 DAS compared to other treatments. At 180 DAS, no significant difference was observed. At 270 DAS the influence of soil (1/3) : sand (1/3) : FYM (1/3) and soil (1/2) : sand (1/3) : neemcake (1/6) was significant.

Table 30. Growth characters of *Dalbergia latifolia* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)			Number of leaves plant^{-1}			Collar diameter (mm)		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	25.4	51.6	64.0	15.2	27.0	64.0	10.1	12.3	7.4	2.9	3.9	5.2
T_2	29.1	48.4	62.3	17.0	22.5	27.2	10.6	11.5	2.7	3.1	4.4	5.4
T_3	27.7	55.1	64.8	16.1	25.8	27.8	10.1	19.7	5.7	2.6	5.3	5.8
T_4	16.4	34.4	36.6	13.7	24.8	22.4	9.3	9.5	3.2	2.1	4.3	4.5
SEm ±	1.33	5.15	5.39	2.15	1.85	2.92	0.58	2.99	1.1	0.17	0.46	0.50
CD (0.05)	3.89	15.02	15.7	NS	NS	8.52	NS	8.72	3.20	0.49	1.34	NS

Table 31. Dry matter accumulation of *Dalbergia latifolia* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot weight (g)			Root weight (g)			Leaf weight (g)			Root:shoot ratio		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	0.37	2.30	4.31	0.31	3.66	6.24	1.38	3.10	2.27	0.20	0.75	1.07
T_2	0.56	2.79	3.61	0.55	3.99	5.33	1.90	3.72	0.76	0.22	0.63	1.32
T_3	0.41	4.42	3.67	0.44	5.36	6.94	1.30	5.28	1.44	0.26	0.64	1.52
T_4	0.31	1.98	1.58	0.28	3.98	3.21	0.97	2.82	1.03	0.23	1.26	1.41
SEm ±	0.06	0.74	0.76	0.07	0.87	1.00	0.22	0.89	0.42	0.02	0.19	0.20
CD (0.05)	0.17	2.16	2.21	0.19	NS	2.92	0.64	NS	1.22	0.06	0.55	NS

T_1 - Soil (1/3) + Sand (1/3) + FYM (1/3) T_3 - Soil (1/2) + Sand (1/3) + neemcake (1/6)

T_2 - Soil (1/2) + Sand (1/3) + FYM (1/6) T_4 - Soil (1/2) + Sand (1/2)

3.1.7 Leaf weight

Leaf weight of *Dalbergia* was significantly influenced by soil 1/2 : sand 1/3 : FYM 1/6 at 90 DAS. This registered highest leaf weight compared to other treatments. At 270 DAS the effect of soil (1/3) : sand (1/3) : FYM (1/3) was significantly different.

3.1.8 Root : Shoot ratio

The analysis of the results showed that there was no significant difference between the effect of treatments on root : shoot ratio.

3.1.9 Population count

The effect of media on the population count varied much between the treatments. At 180 DAS soil (1/2) : sand (1/2) outdid the other treatments with respect to the number of plants. At 270 DAS also soil (1/2) : sand (1/2) continued to be the best medium for the survival of the plants (see Table 18).

3.2 Tissue nutrient concentration

3.2.1 Nitrogen

The media could exert significant influence in this species at 90 DAS. At this stage soil 1/3 : sand 1/3 : FYM 1/3 was found to be the best treatment (2.15%) which was on par with soil 1/2 : sand 1/3 : FYM 1/6. Soil 1/2 : sand 1/2 registered the lowest N content. At 180 DAS, the best media was soil 1/2 : sand 1/3 : FYM 1/6 with respect to N content. After 270 DAS, the highest N content was given by soil 1/2 : sand 1/3 : neemcake 1/6. Soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : FYM 1/6 were on par (Table 32).

Regarding N content in the root, seedlings grown in soil 1/3 : sand 1/3 : FYM 1/3 registered a highly significant value at 90 DAS. Soil 1/2 : sand 1/3 : FYM 1/6 recorded the second highest amount of N. There was no significant difference between the effects at 180 DAS and 270 DAS.

3.2.2 Phosphorus

Regarding P content in above ground portion, soil 1/3 : sand 1/3 : FYM 1/3 gave significantly high amounts at 90 DAS and 180 DAS. No significant effects were shown by any other media at these stages. At 270 DAS, soil 1/2 : sand 1/3 : FYM 1/6 also produce statistically significant effects.

Considering root P, a significantly high value was shown by plants grown in soil 1/3 : sand 1/3 : FYM 1/3. At 180 DAS soil 1/2 : sand 1/3 : FYM 1/6 was on par with soil 1/3 : sand 1/3 : FYM 1/3. At 270 DAS soil 1/3 : sand 1/3 : FYM 1/3 caused the highest rise, followed by soil 1/2 : sand 1/3 : neemcake 1/6 and soil 1/2 : sand 1/3 : FYM 1/6.

3.2.3 Potassium

After 90 days of planting, soil 1/3 : sand 1/3 : FYM 1/3 recorded the maximum K percentage and was significantly superior to all other treatments. soil 1/2 : sand 1/3 : neemcake 1/6 was found superior than soil 1/2 : sand 1/3 : FYM 1/6. At 180 DAS soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 were significantly superior to the other treatments. At 270 DAS soil 1/2 : sand 1/3 : FYM 1/6 registered the highest mean value for K.

Table 32. Tissue nutrient concentration (%) of *Dalbergia latifolia* seedlings

Days after sowing	Treatment	Shoot N	Shoot P	Shoot K	Root N	Root P	Root K
	T_1	2.147	0.070	0.680	1.820	0.042	0.383
	T_2	2.100	0.053	0.437	1.493	0.033	0.327
90	T_3	1.820	0.047	0.470	1.352	0.030	0.267
	T_4	1.540	0.047	0.360	1.260	0.033	0.260
	SEm±	0.0904	0.0032	0.0233	0.0674	0.0025	0.0133
	CD(0.05)	0.311	0.011	0.080	0.233	0.0086	0.046
	T_1	2.582	0.077	0.662	2.053	0.060	0.477
	T_2	2.676	0.058	0.460	2.100	0.057	0.337
180	T_3	2.333	0.052	0.588	2.613	0.050	0.337
	T_4	1.991	0.058	0.549	2.240	0.050	0.427
	SEm±	0.1053	0.0032	0.0332	0.1886	0.0017	0.0307
	CD(0.05)	0.307	0.0093	0.0969	NS	0.0059	0.1062
	T_1	2.100	0.092	0.600	1.960	0.050	0.577
	T_2	1.882	0.063	0.694	2.053	0.033	0.493
270	T_3	2.193	0.034	0.592	2.240	0.043	0.577
	T_4	1.447	0.023	0.526	1.400	0.023	0.360
	SEm±	0.0863	0.0025	0.0320	0.2731	0.0017	0.0200
	CD(0.05)	0.2518	0.0073	0.0934	NS	0.0059	0.0692

As regards to root K, soil 1/3 : sand 1/3 : FYM 1/3 recorded significantly higher values at all stages of observation.

3.3 Soil chemical characteristics

3.3.1 Soil pH

pH values were not significantly affected by the treatments. However the values were found to decrease when compared to non cropped area (Table 33).

3.3.2 Electrical conductivity

In general, there was no significant effect on EC due to different rooting media. However at 180 DAS, soil 1/2 : sand 1/3 : neemcake 1/6 produced significantly higher EC values.

3.3.3 Organic carbon

Organic carbon content was found significantly higher in the rooting media of soil 1/2 : sand 1/3 : FYM 1/6 at 90 DAS and again at 270 DAS. The effects of all other rooting media on the content of organic carbon was found insignificant.

3.3.4 Nitrogen

At 90 DAS soil 1/3 : sand 1/3 : FYM 1/3 recorded a significantly high value with respect to total N than any of the rooting medium. After 180 days N content in soil 1/3 : sand 1/3 : FYM 1/3 was significantly higher than the rest of the treatments. A similar trend was shown by available N also.

3.3.5 Phosphorus

Significant increase in the concentration of available P was observed due in the rooting media of soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 at 90 DAS and 180 DAS respectively. Regarding total P, soil 1/2 : sand 1/3 : FYM 1/6 exhibited a significantly higher values than the rest of the treatments.

3.3.6 Potassium

With respect to availabke K, soil 1/2 : sand 1/3 : neemcake 1/6 recorded the highest concentration (179.17 ppm) followed by soil 1/3 : sand 1/3 : FYM 1/3 (133.33 ppm). Soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/2 : sand 1/2 were on par in their K concentration. An exactly similar trend was observed at 270 DAS also.

3.4 Physiological parameters

3.4.1 Relative water content (RWC)

In the present study, it was found that all the rooting media were significantly superior to soil (1/2) : sand (1/2) and were at par in the case of RWC (see Table 22).

3.4.2 Specific leaf area

The leaf area of seedlings as affected by the various treatments is depicted (see Table 23). The media exerted significant influence. Seedlings that grown in soil (1/2) : sand (1/3) : FYM (1/3) had the largest leaf area. Soil (1/2) : sand (1/3) : FYM (1/6) was found to be the next best medium. Plant grown in soil

Table 33. Soil chemical properties (0-15 cm soil layer) under *Dalbergia latifolia* seedlings

Days after sowing	Treatment	pH	EC (dSm^{-1})	OC (%)	Available N ($kg\ ha^{-1}$)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	4.4	0.201	2.233	418.13	13.83	133.33	0.579	0.073	0.343
	T_2	4.5	0.053	2.667	441.13	9.86	83.33	0.429	0.090	0.403
90	T_3	4.1	0.084	2.467	390.96	15.41	158.33	0.457	0.077	0.350
	T_4	4.7	0.030	2.400	353.32	7.03	79.17	0.373	0.090	0.327
	SEm±	0.0909	0.0738	0.1050	30.655	0.8283	33.398	0.0247	0.0054	0.0266
	CD(0.05)	NS	NS	0.3633	NS	2.866	NS	0.0854	NS	NS
	T_1	4.4	0.068	2.098	420.23	13.49	133.33	0.5414	0.087	0.377
	T_2	4.4	0.086	2.392	424.40	8.05	91.67	0.4574	0.110	0.377
180	T_3	4.1	0.100	2.363	390.96	12.92	179.17	0.4574	0.103	0.327
	T_4	4.6	0.073	2.157	342.87	6.23	79.17	0.3734	0.100	0.370
	SEm±	0.0726	0.0081	0.1811	28.88	1.632	14.282	0.0132	0.0062	0.0188
	CD(0.05)	NS	0.028	NS	NS	5.64	49.41	0.0456	0.021	NS
	T_1	4.8	0.063	1.961	430.68	19.04	108.33	0.5226	0.09	0.40
	T_2	4.6	0.141	2.177	351.23	17.11	83.33	0.5786	0.11	0.36
270	T_3	4.4	0.117	1.843	420.23	6.01	220.83	0.5134	0.11	0.39
	T_4	4.4	0.050	1.549	405.59	6.01	83.33	0.532	0.11	0.45
	SEm±	0.1036	0.0393	0.1334	17.37	2.24	12.67	0.0354	0.0057	0.0164
	CD(0.05)	0.358	NS	0.461	60.12	7.74	43.83	NS	0.02	0.056

Table 34. Nutrient uptake by *Dalbergia latifolia* seedlings at different stages

Days after sowing	Treatment	N uptake (mg g^{-1})			P uptake (mg g^{-1})			K uptake (mg g^{-1})		
		Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total
	T_1	37.57	5.64	21.59	1.22	0.13	0.68	11.90	1.18	6.54
	T_2	51.66	8.21	29.94	1.30	0.18	0.75	10.75	1.79	6.27
90	T_3	31.12	5.95	18.04	0.80	0.13	0.47	8.04	1.17	4.61
	T_4	19.71	3.53	11.63	0.60	0.09	0.35	4.61	0.73	2.68
SEm±		0.608	0.574	0.575	0.460	0.011	0.236	0.583	0.024	0.291
CD(0.05)		2.105	1.987	1.989	1.613	0.039	0.816	2.016	0.084	1.008
	T_1	139.43	75.14	107.44	4.16	2.19	3.21	35.75	17.46	26.63
	T_2	174.21	83.79	129.02	3.77	2.27	3.02	29.94	13.45	21.71
180	T_3	226.30	140.05	183.21	5.04	2.68	3.86	57.03	18.06	37.09
	T_4	95.57	89.15	92.35	2.78	1.99	2.36	26.35	16.99	21.48
SEm±		1.379	0.639	0.6508	0.751	0.558	0.644	0.716	0.151	0.344
CD(0.05)		4.773	2.210	2.252	2.598	1.931	2.228	2.478	0.522	1.190
	T_1	138.18	122.30	130.26	6.05	3.12	4.60	39.48	36.00	37.72
	T_2	82.24	109.20	95.84	2.75	1.76	2.26	30.33	26.27	28.31
270	T_3	112.06	155.45	133.69	1.74	2.98	2.35	30.25	40.04	35.26
	T_4	37.76	44.94	41.32	0.60	0.74	0.62	13.73	11.55	12.65
SEm±		1.797	0.519	0.743	0.358	0.467	0.170	0.292	0.288	0.284
CD(0.05)		6.217	1.798	2.571	1.241	1.615	0.588	1.009	0.998	0.982

(1/2) : sand (1/3) : neemcake (1.6) and soil (1/2) : sand (1/2) were significantly inferior.

3.4.3 Chlorophyll content

The data related to chlorophyll content all tabulated (see Table 24). The chlorophyll content of leaves was not significantly influenced by the rooting media.

4 *Hopea parviflora*

The results of the growth characteristics of *Hopea* seedlings grown in different rooting media are presented in Tables 35 and 36.

4.1 Biometric observations

4.1.1 Shoot height

Shoot height was significantly influenced by rooting media treatments at different growth stages. Soil 1/3 : sand 1/3 : FYM 1/3 recorded the highest value for shoot length (22.4 cm) after a period of 180 DAS and was significantly superior to all other treatments.

4.1.2 Root length

Root length was significantly different due to the rooting media treatments at 270 DAS only. The largest root length was in the rooting medium of soil, sand and FYM in the proportion of 1/3 each.

4.1.3 Number of leaves

At 90 DAS the results show that there was no significant difference among different treatments tried with respect to the number of functional leaves. All the four different type of rooting media produced similar effects on the production of leaves. At 180 DAS soil (1/3) : sand (1/3) : FYM (1/3) attained a significant high value in this regard. At the end of the study the number of leaves produced by seedlings grown in soil (1/2) : sand (1/3) : neemcake (1/6) was the highest.

4.1.4 Root collar diameter

Root collar diameter was significantly influenced by rooting media. At 270 DAS, largest root collar diameter was produced by soil 1/3 : sand 1/3 : FYM 1/3. This medium was on par with soil 1/2 : sand 1/3 : FYM 1/6.

4.1.5 Shoot weight

With regard to this parameter, the rooting medium of soil, sand and FYM in the proportion of 1/3 each increased the shoot weight of *Hopea* by 3.2 times compared to the control at 180 DAS. Soil 1/2 : sand 1/3 : FYM 1/6 produced a 2.4 fold increase compared to control. At 270 DAS, more or less similar result was obtained with even wider magnitude of difference.

4.1.6 Root weight

Rooting media has highly significant influence on root weight of Hopea seedlings. At 180 DAS, the rooting media of soil, sand and FYM in the proportion of 1/3 each and in the proportion of 1/2, 1/3 and 1/6 each increased the root weight by 2.6 and 2.4 times respectively compared to the control. At 270 DAS also largest root weight was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each. The rooting medium of soil, sand and FYM or soil, sand

Table 35. Growth characters of *Hopea parviflora* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)		No. of leaves			Collar diameter (mm)	
	90	180	270	180	270	90	180	270	180	270
	(Days after sowing)									
T_1	10.6	22.4	27.5	14.7	20.6	3.9	26.2	34.7	2.4	4.8
T_2	15.6	18.3	24.7	14.8	15.2	4.6	17.4	31.7	2.4	4.0
T_3	15.3	13.1	27.6	15.2	16.8	5.1	18.4	41.4	1.2	4.3
T_4	9.6	14.3	20.4	14.1	14.4	4.6	12.7	25.6	1.7	3.0
SEm ±	0,97	1.57	1.95	1.36	1.57	0.39	3.6	5.0	0.27	0.30
CD(0.05)	2.71	4.58	5.69	NS	4.61	1.14	10.5	14.59	0.79	0.87

Table 36. Dry matter accumulation of *Hopea parviflora* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot weight (g)		Root weight (g)		Leaf weight (g)		Root:shoot ratio	
	180	270	180	270	180	270	180	270
T_1	0.72	1.32	0.43	1.22	1.0	1.78	0.30	0.42
T_2	0.55	0.83	0.40	0.70	0.9	1.59	0.27	0.33
T_3	0.26	0.99	0.24	0.74	0.4	1.79	0.48	0.26
T_4	0.23	0.34	0.16	0.36	0.3	0.97	0.30	0.28
SEm ±	0.10	0.20	0.04	0.17	0.13	0.31	0.11	0.03
CD(0.05)	0.29	0.58	0.12	0.49	0.38	NS	NS	0.08

and neemcake in the proportion of 1/2, 1/3 and 1/6 each were on par and significantly superior to the control.

4.1.7 Leaf weight

The rooting medium of soil, sand and FYM in the proportion of 1/3 each or 1/2, 1/3 and 1/6 significantly increased the leaf weight at 180 DAS compared to the control. At 270 DAS, no significant differences were observed.

4.1.8 Root : shoot ratio

Soil (1/3) : sand (1/3) : FYM (1/3) produced a significant difference in the root : shoot ratio of *Hopea* seedlings at the final stage of observation.

4.1.9 Population count

At 90 DAS soil (1/2) : sand (1/3) : neemcake (1/6) recorded a significantly high value regarding the number of plants. During other stages of observation, soil (1/2) : sand (1/2) registered the highest mean values (see Table 18).

4.2 Tissue nutrient concentration

4.2.1 Nitrogen

The available N content was the highest for soil 1/2 : sand 1/3 : FYM 1/6 followed by soil 1/2 : sand 1/3 : neemcake 1/6. In the case of the other treatments under study, soil 1/2 : sand 1/2 registered the lowest nitrogen content (Table 37).

Effect of rooting medium recorded detectable differences with regard to the N content in the root. At 90 DAS, highest N content was observed with soil 1/3 : sand 1/3 : FYM 1/3. At 180 DAS soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/2 were on par and was superior to others. At 270 DAS only soil 1/2 : sand 1/2 was statistically superior in respect of N percentage.

4.2.2 Phosphorus

Considering the P contribution of different media soil 1/2 : sand 1/3 : neemcake 1/6 continued to be the best in all stages. This was followed by soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/3 : sand 1/3 : FYM 1/3.

The concentration of P in the root was distinctly higher due to soil 1/3 : sand 1/3 : FYM 1/3 at 180 DAS. At 270 DAS, soil 1/2 : sand 1/3 : FYM 1/6 registered the maximum P content.

4.2.3 Potassium

Different rooting medium produced significant differences in the K concentration. Plants grown in soil 1/3 : sand 1/3 : FYM 1/3 recorded the highest K content at all stages of observation. The next best treatment was soil 1/2 : sand 1/3 : neemcake 1/6 followed by soil 1/2 : sand 1/3 : FYM 1/6.

In the case of root also, the influence of medium on K content was significant. Of the treatments tried, soil 1/3 : sand 1/3 : FYM 1/3 was found to be the best and was significantly superior to all other treatments.

Table 37. Tissue nutrient concentration (%) of *Hopea parviflora* seedlings

Days after sowing	Treat-ment	Shoot			Root		
		N	P	K	N	P	K
90	T_1	1.960	0.050	0.583	2.193	0.043	0.610
	T_2	2.287	0.050	0.492	1.960	0.040	0.447
	T_3	2.100	0.057	0.508	1.773	0.040	0.527
	T_4	1.820	0.040	0.392	1.540	0.037	0.377
	SEm ±	0.0467	0.0017	0.0198	0.0587	0.0027	0.0186
	CD(0.05)	0.161	0.0058	0.068	0.203	NS	0.0643
180	T_1	3.064	0.050	0.641	2.847	0.073	0.667
	T_2	2.396	0.062	0.517	2.380	0.050	0.427
	T_3	2.318	0.066	0.638	2.100	0.060	0.543
	T_4	2.116	0.043	0.406	2.987	0.057	0.427
	SEm ±	0.1288	0.0017	0.0230	0.1872	0.0022	0.0188
	CD(0.05)	0.3758	0.0049	0.067	0.6477	0.0076	0.0650
270	T_1	1.758	0.056	0.708	2.053	0.047	0.543
	T_2	2.644	0.057	0.569	1.680	0.063	0.387
	T_3	2.256	0.058	0.719	2.147	0.057	0.683
	T_4	1.913	0.053	0.527	2.847	0.053	0.517
	SEm ±	0.0732	0.0024	0.0296	0.2160	0.0035	0.0203
	CD(0.05)	0.2136	NS	0.0864	0.7474	0.0121	0.0702

4.3 Soil chemical characteristics

4.3.1 Soil pH

Rooting media treatments did not differ in their effect on soil pH. pH values were less in all treatments compared to non cropped areas (Table 38).

4.3.2 Electrical conductivity

At 180 DAS and 270 DAS soil 1/3 : sand 1/3 : FYM 1/3 produced a significantly high value for EC. By and large no other medium produced any significant difference.

4.3.3 Organic carbon

With regard to organic carbon content at 90 DAS the highest value was recorded by soil 1/3 : sand 1/3 : FYM 1/3. The other three rooting media did not have any significant influence in this respect. At 180 DAS, soil 1/3 : sand 1/3 : FYM 1/3 was found to be significantly superior to all other treatments (3.12%). The next best treatment was soil 1/2 : sand 1/3 : neemcake 1/6 followed by soil 1/2 : sand 1/3 : FYM 1/6. The lowest organic carbon content was observed in the medium containing soil 1/2 : sand 1/2 (2.1%).

4.3.4 Nitrogen

Regarding macro-nutrients in the surface (0-15 cm) layer of the soil, soil 1/2 : sand 1/3 : FYM 1/6 had markedly higher content of available nitrogen. The next best treatment was soil 1/3 : sand 1/3 : FYM 1/3. At 270 DAS soil 1/3 : sand 1/3 : FYM 1/3 released the maximum N content, and soil 1/2 : sand 1/3 : FYM 1/6

Table 38. Soil chemical properties (0-15 cm soil layer) under *Hopea parviflora* seedlings

Days after sowing	Treatment	pH	EC (dSm^{-1})	OC (%)	Available N (kg/ha)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	4.6	0.110	3.133	434.86	12.01	204.17	0.532	0.100	0.433
	T_2	4.8	0.082	2.200	503.85	9.07	108.33	0.420	0.097	0.347
90	T_3	4.7	0.115	2.867	386.77	8.73	191.67	0.429	0.103	0.387
	T_4	4.8	0.137	2.467	432.77	9.86	83.33	0.448	0.107	0.403
	SEm±	0.1823	0.0326	0.2459	13.535	0.978	25.882	0.0284	0.0040	0.0261
	CD(0.05)	NS	NS	0.8508	46.83	NS	89.54	0.0982	NS	NS
	T_1	4.5	0.109	3.118	430.68	10.65	154.17	0.532	0.100	0.377
	T_2	4.7	0.082	2.422	466.22	10.88	91.67	0.4854	0.107	0.337
180	T_3	4.5	0.083	2.598	388.86	8.50	166.67	0.4386	0.103	0.383
	T_4	4.5	0.106	2.108	422.31	9.29	83.33	0.532	0.100	0.450
	SEm±	0.0500	0.0065	0.0391	11.046	0.887	9.547	0.0185	0.0022	0.0124
	CD(0.05)	NS	0.022	0.135	38.19	NS	33.03	0.0638	NS	0.043
	T_1	4.4	0.300	1.774	418.13	9.06	179.17	0.4574	0.107	0.403
	T_2	4.6	0.047	1.725	384.68	8.04	108.33	0.4106	0.107	0.360
270	T_3	4.5	0.102	2.118	416.04	9.63	250.00	0.504	0.097	0.437
	T_4	4.5	0.110	1.559	416.04	6.57	79.17	0.6254	0.110	0.360
	SEm±	0.1622	0.0389	0.1127	9.4081	1.1395	9.9187	0.0482	0.0037	0.0110
	CD(0.05)	0.561	0.134	0.390	32.55	NS	34.31	0.1666	NS	0.038

the minimum. Soil 1/2 : sand 1/3 : neemcake 1/6 was almost on par with soil 1/2 : sand 1/2 throughout the growth stages.

Soil 1/3 : sand 1/3 : FYM 1/3 was found to be significantly superior to all other treatments with regard to total nitrogen content at 90 DAS. At 180 DAS, soil 1/3 : sand 1/3 : FYM 1/3 was on par with soil 1/2 : sand 1/2 and significantly superior to the other treatments.

The total N percentage was the highest for soil 1/2 : sand 1/2 at 270 DAS. In the case of the other three treatments under study, all of them produced similar effects on the content of N.

4.3.5 Phosphorus

On 90, 180 and 270 days after sowing the differences among the rooting media were statistically insignficant in respect of available P concentration. Total P content was not significantly affected by rooting media at 90, 180 DAS and 270 DAS, respectively.

4.3.6 Potassium

In the case of available K, at 90 DAS highest K content was given by soil 1/3 : sand 1/3 : FYM 1/3 followed by soil 1/2 : sand 1/3 : neemcake 1/6. The reverse trend was observed at 180 and 270 DAS. The other two treatments were on par on all the three stages.

With regard to total K, no significant difference was produced by rooting media at 90 DAS. at 180 DAS soil 1/2 : sand 1/2 registered a high percentage of K followed by soil 1/2 : sand 1/3 : neemcake 1/6. At 270 DAS soil 1/2 : sand 1/3 :

Table 39. Nutrient uptake by *Hopea parviflora* seedlings at different stages

Days after sowing	Treat-ment	N uptake (mg g^{-1})			P uptake (mg g^{-1})			K uptake (mg g^{-1})		
		Shoot	**Root**	**Total**	**Shoot**	**Root**	**Total**	**Shoot**	**Root**	**Total**
	T_1	52.70	12.24	32.47	0.86	0.31	0.58	11.02	2.87	6.96
	T_2	34.74	9.52	22.15	0.90	0.20	0.55	7.50	1.71	4.64
180	T_3	15.30	5.04	10.17	0.43	0.14	0.29	4.21	1.30	2.77
	T_4	11.21	4.78	7.96	0.23	0.09	0.16	2.15	0.68	1.43
SEm±		0.807	0.498	0.503	0.014	0.013	0.005	0.009	0.317	0.160
CD(0.05)		2.794	1.723	1.742	0.050	0.044	0.016	0.030	1.098	0.553
	T_1	54.50	25.05	39.75	1.74	0.58	1.16	21.95	6.62	13.79
	T_2	63.98	11.76	37.84	1.38	0.44	0.89	13.77	2.71	8.23
270	T_3	62.71	15.88	39.23	1.61	0.42	1.02	19.99	5.05	12.51
	T_4	25.06	10.25	17.68	0.69	0.19	0.44	6.90	1.86	4.39
SEm±		0.1830	1.0255	0.4871	0.0952	0.0241	0.0502	0.2915	0.4741	0.3306
CD(0.05)		0.633	3.548	1.685	0.329	0.0834	0.1737	1.008	1.6404	1.144

neemcake 1/6 recorded the maximum value followed by soil 1/3 : sand 1/3 : FYM 1/3, The other two treatments were on par.

4.4 Physiological parameters

4.4.1 Relative water content (RWC)

In the case of *Hopea*, soil (1/2) : sand (1/3) : FYM (1/6) produced significantly higher values as regards to RWC. All other treatments were statistically inferior in this respect. The next best media was soil (1/3) : sand (1/3) : FYM (1/3) (see Table 22).

4.4.2 Specific leaf area

The data related to leaf area are tabulated (see Table 23). Plants grown in soil (1/3) : sand (1/3) : FYM (1/3) had the smallest leaf area. All other treatments produced significantly higher leaf area in this species and they were at par.

4.4.3 Chlorophyll content

The chlorophyll content of leaves was not significantly influenced by the rooting media (see Table 24). However, seedlings subjected to soil (1/2) : sand (1/2) recorded the lowest total chlorophyll content.

5 *Santalum album*

The observations on the effect of different rooting media on the growth characteristics of *Sandal* seedlings are furnished in Table 40.

5.1 Biometric observations

5.1.1 Shoot height

At 90 DAS, the rooting medium of soil, sand and FYM in the proportion of 1/3 each significantly increased the shoot height. At 270 DAS, the rooting media of soil, sand and FYM in the proportion of 1/3 each and 1/2, 1/3 and 1/6 gave rise to largest shoot height compared to the control.

5.1.2 Root length

Root length was not significantly influenced by the rooting media treatments.

5.1.3 Number of leaves

Compared to the control, all other rooting media gave rise to higher number of functioning leaves at different days of observation. This difference was statistically significant at 90 and 180 DAS respectively.

5.1.4 Collar diameter

Compared to the control, all other rooting media gave rise to higher collar diameter. At 270 DAS soil : sand and FYM (1/3) each and soio 1/2 : sand 1/3 : FYM 1/6 each were statistically superior.

5.1.5 Shoot weight

Soil (1/3) : sand (1/3) : FYM (1/3) produced a significant influence on the shoot weight of sandal seedlings at 270 DAS. Rest of the medium failed to produce any significant effect.

Table 40. Growth characters and dry matter of *Santalum album* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)	No. of leaves plant^{-1}			Collar diameter (mm)	Shoot weight (g)	Root weight (g)	Leaf weight (g)	Root: shoot ratio
	90	180	270	270	90	180	270	270	270	270	270	270
T_1	24.40	25.60	38.00	19.00	5.60	27.80	41.90	4.80	1.79	1.39	1.50	0.46
T_2	7.30	25.60	38.60	18.20	6.30	26.00	41.30	4.70	1.46	0.91	0.98	0.39
T_3	8.40	21.40	33.10	16.00	5.10	25.10	27.70	4.10	1.38	1.21	1.67	0.41
T_4	8.00	12.90	27.30	18.00	4.80	11.90	28.10	3.80	0.70	0.70	0.94	0.41
SEm±	5.26	2.05	3.05	1.91	0.39	2.85	6.40	0.30	0.32	0.25	0.33	0.03
CD(0.05)	15.35	5.98	8.90	NS	1.13	8.31	NS	0.87	0.93	NS	NS	NS

5.1.6 Root weight

Root weight was not significantly affected by the rooting media.

5.1.7 Leaf weight

As could be seen, the influence of rooting media was not significant in the case of leaf weight also.

5.1.8 Root : shoot ratio

The analysis of the results show that there was no significant difference between the treatments on the root : shoot ratio.

5.1.9 Population count

In the case of sandal, at 180 and 270 DAS, soil (1/2) : sand (1/3) : FYM (1/6) showed definite superiority in the number of plants. The minimum number of plants was recorded by soil (1/2) : sand (1/2) at these stages (see Table 18).

5.2 Tissue nutrient concentration

5.2.1 Nitrogen

With regard to the N content, soil 1/3 : sand 1/3 : FYM 1/3 was significantly superior to all treatments after 90 DAS and recorded the maximum content (2.29%). The effect due to soil 1/2 : sand 1/3 : neemcake 1/6 was also significant (2.01%). However at 180 and 270 DAS, none of the rooting medium produced any significant difference with respect to N concentration.

Regarding N content of the roots, soil 1/3 : sand 1/3 : FYM 1/3 outdid the other treatments by producing an average of 1.97 percentage. The performance of soil 1/2 : sand 1/3 : FYM 1/6 was also found good.

5.2.2 Phosphorus

Media could exert significant influence on the P content of this species. At 90 DAS soil 1/3 : sand 1/3 : FYM 1/3 produced the highest concentration (0.059%) followed by soil 1/2 : sand 1/3 : FYM 1/6. These treatments were significantly superior to all other treatments. Soil 1/2 : sand 1/2 was the most inferior medium in this respect, producing only 0.046% of P.

In the case of root P also, seedlings grown in soil 1/3 : sand 1/3 : FYM 1/3 registered highly significant values at 90, 180 and 270 DAS (Table 41). Soil 1/2 : sand 1/3 : FYM 1/6 was almost on par with soil 1/2 : sand 1/3 : neemcake 1/6 throughout the growth stages.

5.2.3 Potassium

Observations recorded at all stages revealed that soil 1/2 : sand 1/3 : neemcake 1/6 is the best medium with respect to K concentration in Sandal seedlings. The next best treatment was soil 1/3 : sand 1/3 : FYM 1/3.

Regarding root K, soil 1/3 : sand 1/3 : FYM 1/3 recorded highest content ranging from 0.55% to 0.64% followed by 0.48 per cent to 0.58 per cent due to soil 1/2 : sand 1/3 : FYM 1/6. Soil 1/2 : sand 1/2 consistently registered the lower values for K at all stages of experimental period.

Table 41. Tissue nutrient concentration (%) of *Santalum album* seedlings

Days after sowing	Treatment	Shoot			Root		
		N	P	K	N	P	K
	T_1	2.287	0.059	0.710	1.867	0.043	0.627
	T_2	1.820	0.052	0.667	1.727	0.038	0.543
90	T_3	2.007	0.048	0.870	1.587	0.034	0.610
	T_4	1.680	0.051	0.753	1.400	0.033	0.537
	SEm±	0.0539	0.0008	0.0277	0.0700	0.0009	0.0196
	CD(0.05)	0.186	0.0027	0.095	0.242	0.0031	0.0678
	T_1	2.007	0.063	1.208	1.960	0.054	0.643
	T_2	2.007	0.061	0.916	1.727	0.050	0.577
180	T_3	2.069	0.050	1.430	1.867	0.050	0.527
	T_4	2.147	0.048	1.010	1.633	0.047	0.470
	SEm±	0.0644	0.0015	0.294	0.0301	0.0017	0.0196
	CD(0.05)	NS	0.0044	0.0858	0.1041	0.0059	0.0678
	T_1	2.380	0.063	1.208	2.100	0.036	0.550
	T_2	2.489	0.068	0.962	2.100	0.023	0.477
270	T_3	2.551	0.051	1.654	1.960	0.030	0.443
	T_4	2.442	0.046	0.971	1.913	0.027	0.360
	SEm±	0.0890	0.0032	0.0790	0.2126	0.0007	0.0133
	CD(0.05)	NS	0.0093	0.2305	NS	0.0024	0.0460

5.3 Soil chemical characteristics

5.3.1 Soil pH

The influence of rooting media was not significant in the case of soil pH.

5.3.2 Electrical conductivity

Among the rooting media tested, none exhibited significant difference in EC at 90 and 270 DAS. At 180 DAS, all rooting media showed significantly higher values except soil 1/2 : sand 1/3 : FYM 1/6.

5.3.3 Organic carbon

There was no significant difference between the effect of treatments on the content of organic carbon in any of the stages. Though all the four different type of growing media produced similar effects, soil 1/2 : sand 1/3 : FYM 1/6 registered higher values at all stages.

5.3.4 Nitrogen

The media could not exert significant influence in the amount of total or available N at any of the stages of observation.

5.3.5 Phosphorus

Available P content was not significantly different among treatments at 90 DAS. At 180 DAS the highest content was recorded by soil 1/3 : sand 1/3 : FYM 1/3 (14.05 ppm). Soil 1/2 : sand 1/2 recorded the lowest value (7.14 ppm). The other two treatments were intermediate with respect to P content.

Table 42. Soil chemical properties (0-15 cm soil layer) under *Santalum album* seedlings

Days after sowing	Treatment	pH	EC (dSm^{-1})	OC (%)	Available N (kg/ha)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	4.7	0.083	2.033	441.13	17.79	91.67	0.383	0.103	0.393
	T_2	4.2	0.062	2.500	462.04	9.63	108.33	0.280	0.090	0.443
90	T_3	4.5	0.086	2.367	439.04	10.77	95.83	0.383	0.100	0.367
	T_4	4.2	0.095	2.033	443.22	13.49	145.83	0.448	0.113	0.337
	SEm±	0.1221	0.0320	0.3230	24.971	4.147	17.800	0.0553	0.0019	0.0131
	CD(0.05)	NS	NS	NS	NS	NS	NS	NS	0.0065	0.045
	T_1	4.6	0.098	2.343	434.86	14.05	100.00	0.4946	0.123	0.403
	T_2	4.2	0.068	2.637	434.86	9.29	108.33	0.3826	0.110	0.403
180	T_3	4.5	0.112	2.167	403.5	10.88	150.0	0.448	0.103	0.363
	T_4	4.4	0.104	2.157	416.04	7.14	104.17	0.364	0.110	0.360
	SEm±	0.1206	0.0083	0.1555	19.529	1.285	13.767	0.0386	0.0025	0.0192
	CD(0.05)	NS	0.028	NS	NS	4.44	47.61	NS	0.0086	NS
	T_1	4.5	0.145	2.039	416.04	22.10	100.00	0.532	0.127	0.387
	T_2	4.7	0.142	2.176	393.05	12.01	108.33	0.616	0.117	0.393
270	T_3	4.6	0.118	1.892	403.50	7.59	241.67	0.5786	0.110	0.370
	T_4	4.7	0.079	2.108	397.23	5.89	87.50	0.5506	0.107	0.420
	SEm±	0.2303	0.0440	0.0830	8.297	1.2531	13.767	0.0314	0.0029	0.0225
	CD(0.05)	NS	NS	NS	NS	4.33	47.61	NS	0.010	NS

Table 43. Nutrient uptake by *Santalum album* seedlings at different stages

Days after sowing	Treat-ment	N uptake (mg g^{-1})			P uptake (mg g^{-1})			K uptake (mg g^{-1})		
		Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total
	T_1	78.30	29.19	53.72	2.07	0.50	1.28	39.74	7.64	23.70
	T_2	60.73	19.11	39.92	1.66	0.21	0.93	23.47	4.34	13.90
270	T_3	77.80	23.71	50.78	1.56	0.36	0.93	50.45	5.36	27.93
	T_4	40.05	13.39	26.73	0.75	0.19	0.47	15.92	2.52	9.20
SEm±		1.238	0.863	0.524	0.313	0.025	0.164	0.284	0.008	0.143
CD(0.05)		4.284	2.987	1.814	1.084	0.085	0.567	0.982	0.027	0.495

Regarding total P at 90 DAS, soil 1/2 : sand 1/2 was found to be significantly superior to other treatments. Soil 1/3 : sand 1/3 : FYM 1/3 and soil 1/2 : sand 1/3 : neemcake 1/6 were on par. Soil 1/2 : sand 1/3 : FYM 1/6 recorded the smallest content. Soil 1/3 : sand 1/3 : FYM 1/3 was found superior at 180 and 270 DAS. The next best medium was soil 1/2 : sand 1/3 : FYM 1/6 at 270 DAS.

5.3.6 Potassium

The media could produce significant influence on the concentration of available K at 180 DAS. Soil 1/2 : sand 1/3 : neemcake 1/6 gave the highest mean value for available K which was significantly superior to all other treatment at 180 and 270 DAS. Regarding total K, soil 1/2 : sand 1/3 : FYM 1/6 recorded significantly higher values followed by soil 1/3 : sand 1/3 : FYM 1/3 at 90 DAS. There was no significant difference between treatments at 180 and 270 DAS.

5.4 Physiological parameters

5.4.1 Relative water content (RWC)

Treatment differences were found to be significant with regard to this parameter (see Table 22). Seedlings grown in soil (1/2) : sand (1/3) : FYM (1/6) registered the maximum value for RWC. Second highest content was shown by soil (1/3) : sand (1/3) : FYM (1/3).

5.4.2 Specific leaf area

Specific leaf area increased significantly for plants grown in soil (1/2) : sand (1/2) : FYM (1/6) and soil (1/2) : sand (1/3) : neemcake (1/6). The other treatment had no significant effect (see Table 23).

5.4.3 Chlorophyll content

The chlorophyll 'a' content differed significantly between the various treatments (see Table 24). Seedlings grown in soil (1/2) : sand (1/2) had the highest (1.071 mg g^{-1}) chlorophyll 'a' content. Regarding chlorophyll 'b' content, the difference between the treatments was statistically non-significant. With regard to total chlorophyll content, the treatments were in the order soil (1/2) : sand (1/2) > soil (1/2) : sand (1/3) : FYM (1/6) > soil (1/3) : sand (1/3) : FYM (1/3) > soil (1/2) : sand (1/3) : neemcake (1/6).

6 *Tectona grandis*

Data pertaining to the influence of the media on the growth characters of *Teak* seedlings are presented in Tables 44 and 45.

6.1 Biometric observations

6.1.1 Shoot height

Significant differences in shoot height were observed due to the rooting medium treatments. At 90 DAS rooting medium of soil, sand and FYM in the proportion of 1/3 each increased the shoot height by 3.9 times compared to the control. The rooting medium of soil, sand and FYM and soil, sand and neemcake in the proportion of 1/2, 1/3 and 1/6 respectively increased the shoot height by 2.9 times compared to the control. At 180 DAS, more or less similar trend was maintained. At 270 DAS, all rooting media treatments were significantly superior to control and were on par.

6.1.2 Root length

During the first three months, length of the main root did not show any significant difference due to treatment application. At 180 DAS significant differences were brought about by soil (1/2) : sand (1/3) : FYM (1/6). At 270 DAS it was replaced by soil : sand : FYM 1/3 each. All other treatments were on par with the control.

6.1.3 Number of leaves

More or less similar results as in the case of root length was observed.

6.1.4 Collar diameter

Observations related to collar diameter of seedlings showed that treatment differ among themselves throughout the study period. At 90 DAS all the three treatments were found statistically superior to soil (1/2) : sand (1/2). At 180 DAS only the rooting medium of soil : sand and FYM in the proportion of 1/3 each was significantly superior to the control. At 270 DAS soil 1/2 : sand 1/2 was significantly inferior to the rest of the treatments.

6.1.5 Shoot weight

Significant difference in shoot weight was observed due to the rooting media treatments. At 90 DAS, rooting medium of soil 1/3 : sand 1/3 : FYM 1/3 increased the shoot weight by about 10 times compared to the control; at 270 DAS, this increase was about 5 times. The rooting medium of soil, sand and FYM or soil, sand and neemcake in the proportion of 1/2, 1/3 and 1/6 increased the shoot weight

Table 44. Growth characters and dry matter of *Tectona grandis* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot height (cm)			Root length (cm)			No. of leaves			Collar diameter (mm)		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	45.6	73.2	69.3	16.2	28.4	35.4	8.7	5.4	5.6	6.4	10.1	10.8
T_2	34.1	53.5	66.6	13.4	32.6	27.7	9.8	9.1	1.9	5.6	7.87	9.9
T_3	31.5	45.0	68.7	17.5	29.4	20.2	9.2	6.0	1.9	5.8	8.41	10.6
T_4	11.6	21.9	23.3	13.1	27.7	23.6	10.0	7.0	2.7	3.4	6.83	7.4
SEm ±	2.19	3.43	2.88	2.06	1.30	2.73	0.62	1.17	0.97	0.58	1.03	0.60
CD (0.05)	6.40	10.03	8.42	NS	3.79	7.97	NS	3.41	2.85	1.69	3.00	1.77

Table 45. Dry matter accumulation of *Tectona grandis* seedlings at different stages of growth as affected by rooting media

Rooting media	Shoot weight (g)			Root weight (g)			Leaf weight (g)			Root:shoot ratio		
	90	180	270	90	180	270	90	180	270	90	180	270
	(Days after sowing)											
T_1	2.65	12.74	10.00	1.27	11.7	13.5	4.07	8.69	0.46	0.18	0.62	1.30
T_2	1.36	6.79	7.65	0.88	10.5	11.1	2.72	8.28	0.58	0.22	0.77	1.32
T_3	1.32	6.89	8.37	1.14	9.98	6.04	2.66	9.39	0.32	0.28	0.79	0.74
T_4	0.27	1.73	1.87	0.56	5.72	7.79	1.07	3.66	0.53	0.45	1.81	3.42
SEm ±	0.32	1.58	1.28	0.20	1.63	2.11	0.57	1.81	0.18	0.03	0.36	0.20
CD (0.05)	0.94	4.60	3.74	0.58	4.75	NS	1.69	5.28	NS	0.08	1.05	0.60

T_1 - Soil (1/3) + Sand (1/3) + FYM (1/3) T_3 - Soil (1/2) + Sand (1/3) + neemcake (1/6)

T_2 - Soil (1/2) + Sand (1/3) + FYM (1/3) T_4 - Soil (1/2) + Sand (1/2)

by five times compared to the control at 90 DAS. Similar trend was maintained at 180 and 270 DAS.

6.1.6 Root weight

Seedlings grown in soil (1/3) : sand (1/3) : FYM (1/3) registered a significant difference compared to soil (1/2) : sand (1/2) at 90 DAS. At 180 DAS soil : sand and FYM 1/3 each and 1/2 : 1/3 : 1/6 each were statistically significant and they were on par. At 270 DAS soil : sand : FYM 1/3 each produced the highest root weight, though the difference were not statistically different.

6.1.7 Leaf weight

Leaf weight was significantly influenced by the rooting medium treatments at 90 DAS. The rooting medium of soil, sand and FYM in the proportion of 1/3 each significantly increased the leaf weight by about 4 times compared to the control. Even though the rooting medium of soil, sand and FYM or soil, sand and neemcake in the proportion of 1/2, 1/3 and 1/6 increased the leaf weight by about 3 times, the difference was not statistically significant. At 180 DAS soil (1/2 : sand (1/3) : neemcake (1/6) showed statistical differences in leaf weight. At 270 DAS this parameter was not found to be statistically influenced by any of the rooting media treatments.

6.1.8 Root : shoot ratio

Compared to the control, all the rooting media treatments significantly reduced the root : shoot ratio by almost half at 90 DAS. At 270 DAS, this difference widened by more than 2.5 times.

6.1.9 Population count

With regard to the number of plants soil (1/2) : sand (1/2) proved to be the best medium for teak seedlings. The second best medium was soil (1/2) : sand (1/3) : FYM (1/6) (see Table 18).

6.2 Tissue nutrient concentration

6.2.1 Nitrogen

With regard to the N concentration, soil 1/3 : sand 1/3 : FYM 1/3 recorded the highest content and was significantly superior to all other treatments. Besides this soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/2 : sand 1/3 : neemcake 1/6 exhibited markedly higher N content compared to soil 1/2 : sand 1/2 (control) at 90 DAS. At 180 DAS only soil 1/3 : sand 1/3 : FYM 1/3 registered a significant influence and at 270 DAS, none of the treatment was statistically significant (Table 46).

Considering root N content, soil 1/3 : sand 1/3 : FYM 1/3 was again found to be significantly superior to all other treatments. At 180 DAS soil, sand, FYM and soil, sand, neemcake in the proportion of 1/2, 1/3 and 1/6 were statistically significant and were on par.

6.2.2 Phosphorus

Considering the P content, only soil 1/3 : sand 1/3 : FYM 1/3 could significantly influence the level of P at 90 and 180 DAS. Other media could exert significant influence at 270 DAS only. Soil 1/3 : sand 1/3 : FYM 1/3 was on par with soil 1/2 : sand 1/3 : FYM 1/6 and was significantly superior to the other

Table 46. Tissue nutrient concentration (%) of *Tectona grandis* seedlings

Days after sowing	Treatment	Shoot			Root		
		N	P	K	N	P	K
	T_1	2.007	0.093	1.177	1.960	0.077	0.743
	T_2	1.727	0.080	0.817	1.680	0.060	0.550
90	T_3	1.493	0.080	1.043	1.633	0.050	0.510
	T_4	1.120	0.077	0.760	1.447	0.033	0.300
	SEm±	0.0381	0.0022	0.0210	0.0725	0.0022	0.0136
	CD(0.05)	0.1318	0.0076	0.073	0.251	0.0076	0.046
	T_1	2.038	0.102	1.497	2.193	0.110	0.787
	T_2	1.742	0.090	0.963	2.007	0.090	0.637
180	T_3	1.773	0.092	1.234	1.820	0.107	0.810
	T_4	1.711	0.093	0.924	1.540	0.083	0.777
	SEm±	0.0630	0.0023	0.0309	0.0797	0.0027	0.0345
	CD(0.05)	0.1838	0.0067	0.0901	0.2757	0.0093	0.1194
	T_1	1.758	0.104	1.189	1.913	0.083	0.987
	T_2	1.649	0.098	1.049	1.727	0.063	0.843
270	T_3	1.836	0.048	1.120	1.633	0.050	0.860
	T_4	1.773	0.043	0.450	1.960	0.030	0.583
	SEm±	0.0646	0.0044	0.0202	0.2282	0.0019	0.0218
	CD(0.05)	NS	0.0128	0.0589	NS	0.0066	0.0754

treatments. There was significant differences between the effect of treatments with respect to root P content. The superiority of significance was in the order of soil 1/3 : sand 1/3 : FYM 1/3 > soil 1/2 : sand 1/3 : FYM 1/6 > soil 1/2 : sand 1/3 : neemcake 1/6 > soil 1/2 : sand 1/2.

6.2.3 Potassium

As regards to K content, the media that could produce a favourable effect in all the three stage was soil 1/3 : sand 1/3 : FYM 1/3. Soil 1/2 : sand 1/3 : neemcake 1/6 was also significantly superior to other treatments. Soil 1/2 : sand 1/2 invariably recorded the lowest values throughout the experimental period.

In the case of root K, highest mean value was recorded by soil 1/3 : sand 1/3 : FYM 1/3 at all stages of observation. The next best treatment was soil 1/2 : sand 1/3 : neemcake 1/6. The medium that gave lowest K content was soil 1/2 : sand 1/2.

6.3 Soil chemical characteristics

6.3.1 Soil pH

The effect of rooting media on soil pH did not differ among themselves. However it appeared that pH registered lower values in all treatments than non cropped field (Table 47).

6.3.2 Electrical conductivity

A significant influence due to rooting medium on EC was noticed in 270 DAS only. At this stage soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/2 : sand 1/3 : neemcake 1/6 produced significantly higher values than the other treatments.

6.3.3 Organic carbon

All the treatments produced similar effects on the soil organic carbon content at 90 DAS. After 180 days of planting, soil organic carbon status in the soil 1/3 : sand 1/3 : FYM 1/3 was significantly higher (2.75%) than soil 1/2 : sand 1/3 : FYM 1/6 and soil 1/2 : sand 1/2. Soil 1/2 : sand 1/3 : neemcake 1/6 was on par with soil 1/3 : sand 1/3 : FYM 1/3. At 270 DAS organic carbon content in soil 1/2 : sand 1/3 : FYM 1/6 was significantly higher than that of the remaining treatments. Soil 1/2 : sand 1/3 : neemcake 1/6 and soil 1/2 : sand 1/2 were on par.

6.3.4 Nitrogen

Total N content was not significantly affected by the rooting medium at any of the stages.

At 270 DAS, soil 1/3 : sand 1/3 : FYM 1/6 and soil 1/2 : sand 1/3 : neemcake 1/6 produced significant effects on available N.

6.3.5 Phosphorus

The total P content was statistically significant for soil 1/2 : sand 1/3 : neemcake 1/6 followed by soil 1/3 : sand 1/3 ; FYM 1/3 and soil 1/2 : sand 1/3 : FYM 1/6. Soil 1/2 : sand 1/2 recorded the lowest content. At 180 DAS, soil 1/3 : sand 1/3 : FYM 1/3 recorded significantly high values for available P. In the case of other treatments under study, no significant effect was noticed at this stage for these nutrients. Almost a similar trend was seen at 270 DAS.

Table 47. Soil chemical properties (0-15 cm soil layer) under *Tectona grandis* seedlings

Days after sowing	Treatment	pH	EC (dSm^{-1})	OC (%)	Available N (kg/ha)	Available P (ppm)	Available K (ppm)	Total N (%)	Total P (%)	Total K (%)
	T_1	4.2	0.072	2.100	434.86	5.21	125.00	0.364	0.097	0.477
	T_2	4.5	0.366	1.200	480.85	6.23	75.00	0.392	0.097	0.370
90	T_3	4.2	0.081	2.367	411.86	7.48	179.16	0.355	0.110	0.410
	T_4	4.6	0.141	1.467	384.68	6.68	100.00	0.355	0.073	0.320
	SEm±	0.0967	0.1518	0.3038	46.293	0.8127	35.661	0.0661	0.0040	0.0235
	CD(0.05)	NS	NS	NS	NS	NS	Ns	Ns	0.013	0.081
	T_1	4.3	0.096	2.745	424.41	12.81	125.00	0.392	0.100	0.413
	T_2	4.4	0.097	1.990	451.58	7.03	79.16	0.448	0.103	0.363
180	T_3	4.1	0.096	2.510	393.05	6.46	150.00	0.392	0.103	0.377
	T_4	4.4	0.089	1.333	363.78	5.78	95.83	0.3454	0.100	0.353
	SEm±	0.0811	0.0153	0.1118	31.103	1.376	17.137	0.0415	0.0025	0.0167
	CD(0.05)	NS	NS	0.387	NS	4.76	NS	NS	NS	0.058
	T_1	4.8	0.047	1.471	399.32	21.76	125.00	0.448	0.103	0.320
	T_2	4.5	0.143	2.304	445.31	9.63	95.83	0.5134	0.107	0.377
270	T_3	4.6	0.146	1.951	449.49	4.98	141.67	0.4946	0.117	0.293
	T_4	4.7	0.056	1.804	380.50	5.78	95.83	0.4946	0.100	0.450
	SEm±	0.1424	0.0268	0.0740	14.06	1.24	17.14	0.0372	0.0032	0.0231
	CD(0.05)	NS	0.092	0.256	48.64	4.29	NS	NS	0.011	0.079

Table 48. Nutrient uptake by *Tectona grandis* seedlings at different stages

Days after sowing	Treatment	N uptake (mg g^{-1})			P uptake (mg g^{-1})			K uptake (mg g^{-1})		
		Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total
	T_1	134.87	24.89	79.88	6.25	0.98	3.62	80.13	9.44	44.78
	T_2	70.46	14.78	42.62	3.26	0.53	1.89	33.33	4.84	19.08
90	T_3	59.42	18.61	39.01	3.18	0.57	1.88	41.51	5.81	23.66
	T_4	15.00	8.10	11.55	1.03	0.18	0.60	1.02	1.68	1.35
SEm±		1.543	1.026	1.284	0.238	0.377	0.307	0.197	0.391	0.294
CD(0.05)		5.338	3.550	4.442	0.823	1.304	1.062	0.681	1.353	1.017
	T_1	436.74	256.58	346.59	21.86	12.87	17.35	320.81	92.08	206.34
	T_2	262.52	210.73	236.52	13.56	9.45	11.52	145.12	66.88	105.99
180	T_3	288.64	181.64	234.99	14.98	10.68	12.79	200.89	80.84	140.84
	T_4	92.22	121.62	106.91	5.01	4.75	4.92	49.80	44.44	47.20
SEm±		1.240	16.675	8.675	0.036	0.037	0.015	0.109	0.266	0.134
CD(0.05)		4.290	57.69	30.01	0.124	0.129	0.051	0.379	0.922	0.463
	T_1	183.88	258.25	221.19	10.88	11.20	11.06	124.37	133.24	128.95
	T_2	135.71	191.69	163.68	8.06	6.99	7.53	86.33	93.57	89.98
270	T_3	159.55	98.63	129.05	4.17	3.02	3.60	97.33	51.94	74.67
	T_4	42.55	152.68	93.12	1.03	2.34	1.69	10.80	45.41	28.11
SEm±		5.419	1.143	2.859	0.358	0.551	0.419	0.517	0.495	0.505
CD(0.05)		18.650	3.950	9.894	1.449	1.241	1.908	1.788	1.715	1.749

6.3.6 Potassium

Regarding total K, soil 1/3 : sand 1/3 : FYM 1/3 produced a significant effect over other treatments at 90 and 180 DAS. The next best medium was soil 1/2 : sand 1/3 : neemcake 1/6 in this respect. But at 270 DAS, soil 1/2 : sand 1/2 produced the highest mean value (0.45%) which was on par with soil 1/2 : sand 1/3 : FYM 1/6. With respect to available K, no significant effect was noticed by any of the medium throughout the growth.

6.4 Physiological parameters

6.4.1 Relative water content (RWC)

The RWC differed significantly between the various treatments. Seedlings grown in soil (1/2) : sand (1/3) : neemcake (1/6) had the highest RWC (79.76%) followed by soil (1/2) : sand (1/2). The other two treatments were inferior with respect to RWC (see Table 26).

6.4.2 Specific leaf area

The media exerted significant influence on leaf area. Seedlings grown in soil (1/2) : sand (1/3) : neemcake (1/6) was significantly inferior to that planted in soil (1/2) : sand (1/2) (see Table 27). Soil (1/2) : sand (1/3) : FYM (1/6) gave the highest leaf area (168.29 cm^2 g^{-1}) and the lowest leaf area was observed in soil (1/2) : sand (1/3) : neemcake (1/6) which recorded a value of 119.93 cm^2 g^{-1}.

6.4.3 Chlorophyll content

Chlorophyll content could not be found out accurately due to the interaction of phenolic exudates and the method has to be modified for estimation of chlorophyll content in teak.

Discussion

DISCUSSION

Results generated from the studies conducted to standardise the rooting media of some forest tree seedlings based on the growth characteristics and nutrient content are discussed hereunder.

Overall growth performance of tree seedlings was significantly influenced by various types of media as evidenced from the statistical analysis of the data. Soil as a medium was found to be inferior in general.

The height, root length, leaf production and leaf area, collar girth, dry matter production, nutrient uptake and some physiological parameters are considered as important criteria for measuring vigour of seedlings.

EXPERIMENT-I

AILANTHUS

Rooting media significantly influenced the height of Ailanthus seedlings. Among the media tried, soil, sand and FYM 1/3 each produced maximum shoot length at all stages of seedling growth. The better aeration of sand, nutrient supplying capacity of soil, water holding and moisture retention capacities coupled with organic matter content of FYM may be the probable reasons for the positive influence of these components on the growth of seedlings. This has been proved in various other tree species also. Regarding root length it was seen that the growth in saw dust or coir dust was significantly inferior compared to the control. This may be due to the poor nutrient status of saw dust and coir dust. A similar finding with saw dust and coir dust was also reported by Hendromono (1988).

The different media expressed their efficiencies in terms of the number of leaves produced. In the present study it was found that soil, sand and FYM (1/3) each was the better media with respect to this. As leaves are the photosynthesizing units of a plant, apart from the leaf area, higher the number of leaves, higher the benefit to the plant in the form of stored food materials. Hence a medium which could produce shoots with higher number of leaves is to be selected.

With respect to collar diameter, media containing soil, sand and FYM 1/3 each and soil 2/3 and FYM 1/3 gave better performance.

Dry weights of shoot, root and leaf were found highest with the media containg soil, sand and FYM in the proportion of 1:1:1. The next best treatment was soil and FYM in the ratio of 2/3 and 1/3 each. Dhar *et al.* (1992) in their studies on the influence of growing media on the growth and dry matter accumulation of *Leucaena leucocephala* observed that FYM was the best medium for raising healthy and vigorous seedlings.

Significant reduction in the root : shoot ratio was observed in *Ailanthus* due to the rooting media of soil and FYM in the ratio of 2/3 and 1/3 each. It was noticed by Singh and Sharma (1983) that addition of humus (25, 50, 75 and 100%) to nursery soil improved the growth of spruce and silver fir. It reduced the root : shoot ratio in spruce, but not in fir. Addition of humus significantly increased the over all growth.

The lowest soil organic carbon status was recorded by seedlings grown in soil + sand + FYM 1/3 each. Regarding nitrogen and potassium content, the least concentration was noticed in soil 2/3 + FYM 1/3 and soil + sand + FYM 1/3 each. This may be due to the better absorption of easily available nutrients from the media of soil, sand and FYM.

In the case of phosphorus soil 2/3 + FYM 1/3 and soil, sand and FYM 1/3 each recorded the highest concentration and this may be due to the high content of P released from the FYM used in the medium.

From the results generated it was found that soil, sand and FYM 1/3 each favourably affected the shoot length, root development, leaf production, diameter growth etc. compared to other media. Hence it can be considered as a better medium.

ALBIZIA

The differences observed in the shoot length of Albizia when grown in eight different types of rooting media were highly significant. Rooting media containing soi, sand and FYM 1/3 each was the most superior medium producing tallest shoots. Length of shoot can be considered as a positive attribute as it can produce more functional leaves.

Root length of Albizia was found longest when grown in the rooting medium of soil, sand and FYM in the proportion of 1/3 each.

Collar girth was also reported to be high in the media of soil, sand and FYM 1/3 each.

Regarding the dry matter accumulation, seedlings grown in soil and FYM in the proportion of 2/3 and 1/3 each and soil, sand and FYM 1/3 each produced maximum dry weights of shoot, root and leaf.

The rooting media containing FYM resulted in lowest root : shoot ratio.

With regard to organic carbon, nitrogen and potassium content, the most inferior media at the end of the study was soil, sand and FYM in the proportion of 1/3 each. Higher absorption rates of nutrients by the seedlings can be a probable reason for this.

The data on the growth characteristics and dry matter production revealed that soil, sand and FYM (1/3 each) was the top ranking rooting medium when compared to the rest of the media.

CASUARINA

The seedlings showed significant differences in shoot height due to treatment effect. Maximum shoot length was observed with the media containing FYM as one component. In the case of root length also, the longest tap root was found with seedlings grown in soil, sand and FYM 1/3 each. The next best treatment was soil and FYM in the ratio of 2/3 and 1/3 each. A similar effect was seen in the case of collar girth. Regarding dry matter accumulation, the superior media was soil and FYM in the proportion of 2/3 and 1/3 each.

With regard to organic carbon, nitrogen and potassium, a more or less similar distribition pattern was observed in the media studied. Soil + sand + FYM (1/3) each consistently recorded the lowest status with respect to the above nutrients probably due to their higher rates of absorption by the growing seedlings.

But in the case of phosphorus, soil + sand + FYM recored a four times higher value compared to control. This may be an indication of the high concentration of phosphorus released in this medium.

The positive trend in growth characteristics shown by the medium, soil + sand + FYM indicates a better availability and absorption of plant nutrients from the medium.

GMELINA

The largest increase in the shoot length of Gmelina was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each. Again this was the superior medium with respect to the root length also. Largest collar diameter of *Gmelina* was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each at the initial stages. Considering the leaf production, soil + sand + FYM 1/3 each produced maximum leaf number.

Regarding dry matter accumulation, the rooting media containing soil, sand and FYM 1/3 each recorded the maximum dry weights at the initial growth period. Compared to the control, all other rooting media treatments significantly reduced the root : shoot ratio of *Gmelina*, largest reduction being noticed in the case of soil, sand and FYM in the proportion of 1/3 each.

With regard to soil organic carbon status, N, P and K, soil + sand + FYM 1/3 each recorded the highest value. The lowest percentage was noticed in soil + sand.

Hazara and Tripathi (1986) reported that biomass production is a function of the phosotynthetically active leaf mass. The reduction in active photosynthetic leaf surface is probably the most important factor affecting overall plant growth rate (Watson, 1952). The present study also highlights the relationship between leaf area and biomass production. It can be presumed that the available solar energy was more effectively utilized by seedlings in soil + sand + FYM 1/3 each by their leaf number and leaf area.

MAHOGANY

Rooting media significantly influenced the shoot length of Mahogany. The media containing soil, sand and FYM in the proportion of 1/3 each was found to be the best medium for increasing the shoot length. The second best medium was soil and FYM in the ratio of 2/3 and 1/3 each.

In the case of root length, no definite trend could be observed due to the differential response of treatments during different stages of growth. Similarly in the case of the number of functional leaves an erratic trend was observed.

Largest increase in the collar diameter was observed in the rooting medium of soil, sand and FYM in the proportion of 1/3 each.

Dry matter accumulation was found highest in the rooting medium of soil, sand and FYM in equal proportions especially at early stages.

Largest reduction in root : shoot ratio was noticed in the case of soil, sand and FYM in the proportion of 1/3 each.

Regarding the nutrients, phosphorus and potassium content were found to be high in the medium of soil + sand + FYM (1/3) each. However, regarding the distribution of organic carbon and nitrogen, this medium was found to be poor. A probable reason for this can be due to the better absorption of these nutrients by the seedlings. High vegetative growth in the medium, soil, sand and FYM 1/3 each is an indication of high N content. Adams and Attiwill (1984) suggested that relative abundance of nitrogen in the plant vegetative parts shows the efficiency of utilizing N which plays a key role in the metabolism of living cells probably leading to faster cell expansion and cell division which might result in higher vegetative growth rates. This view is supported by the present experimental results.

TEAK

Soil, sand and FYM in the proportion of 1/3 each gave rise to largest increase in shoot length.

The different rooting media failed to produce any significant effect on the root length of teak at any of the stages of observation.

Data pertaining to the leaf number was not dependable due to leaf shedding on account of its deciduous character.

Collar girth was more due the rooting medium containing soil and FYM in the ratio of 2/3 and 1/3 each. This was followed by soil, sand and FYM 1/3 each.

Regarding the dry matter production soil and FYM in the ratio of 2/3 and 1/3 recorded the highest dry weights of shoot, root and leaf followed by soil, sand and FYM 1/3 each.

Soil, sand and FYM in the proportion of 1/3 each resulted in a highly significant reduction in the root : shoot ratio of teak.

The nutrient content of soil, sand and FYM 1/3 was found high compared to other treatments especially in phosphorus and organic carbon.

Zech and Dreschsel (1991) reported that teak has a high nutrient requirement. Deficiency of mineral elements in the soil has significantly reduced height growth and dry matter production in teak.

The teak seedlings grown in the medium of soil, sand and FYM 1/3 each were found superior to other treatments regarding growth and absorption characteristics of nutrients.

VATERIA

Shoot length and root length of Vateria was not significantly affected by the different rooting media tried. Number of functional leaves was maximum in the control followed by soil, sand, saw dust 1/3 each. Next to control maximum collar girth was recorded by soil, sand and saw dust in the proportion of 1/3 each. Regarding dry matter production, soil, sand, saw dust 1/3 each registered the maximum dry weight in shoot, root and leaf.

Considering soil nutrients the medium, soil, sand and FYM 1/3 each and soil, sand and saw dust 1/3 each were deficient in organic carbon, nitrogen, phosphorus and potassium. In the present study also indicates higher depletion of nutrients from the above medium.

Garcia *et al.* (1983) reported that for nang seeds to germinate, best media were reported to be saw dust and a mixture of sand and saw dust.

Eusebio *et al.* (1984) observed that a potting mixture of saw dust and soil in equal proportion influenced the growth of *Albizia falcataria* and *Pterocarpus indicus* seedlings significantly compared to saw dust or soil when used alone.

A positive trend shown by a mixture of soil + sand + saw dust 1/3 each may be due to improved aeration and high water retention ability of the medium. The increase in tap root length may be attributed to the ease in penetration and passage afforded to the main root by the medium.

EXPERIMENT-II

ALBIZIA

Data pertaining to the effect of different media on the growth characteristics of Albizia showed that soil, sand and FYM in the proportion of (1/3) each was the most superior medium. The increased shoot and root length, better collar diameter and more number of functional leaves and high dry matter accumulation is an indication of the superiority of the medium.

The favourable influence of the medium may be attributed to its ability to provide an optimum moisture and aeration besides supplying the essential plant nutrients.

In the cultivation of a crop, the extent of mortality is an important criterion. Thus, the percentage of survival also becomes important in assessing the suitability of the media. The physico chemical nature of the components used, the management practices, climatic condition, the plant material used etc. also contribute towards this aspect.

In the present study it was found that the survival was very high in soil (1/2) : sand (1/2). Tanukit (1966) had observed that smaller sized stumps were obtained when sand was used as a germination medium for teak seeds even though the plant population and seedling height was better in sand than in soil.

Regarding the tissue nutrient concentration, seedlings grown in soil, sand and FYM 1/3 each consistently registered higher values for N, P and K in both the above ground and underground plant parts.

The physico-chemical properties of the soil under Albizia seedlings tested showed significant variations at different stages of growth. Except phosphorus, the rooting media containing soil, sand and FYM (1/3) each recorded allow content of organic carbon, available N and potassium. Higher rate of nutrient absorption by the growing seedlings might be a probable reason for this.

When the physiological parameters were observed, the seedlings from the medium, soil, sand and FYM (1/3) each showed highest relative water content. This again shows the superiority of the medium for better water absorption and retention qualities there by increasing the amount of available water to the seedlings. This might have increased the speed of germination and various enzymatic activities, and thereby resulting in the higher biomass production of the seedlings.

The chlorophyll content of leaves was not significantly influenced by the rooting media. The data pertaining to the leaf area showed that soil, sand, FYM

(1/3) each was the superior medium. More the leaf area, more would be the photo interception and stored energy. So the media which could help the plants in producing more leaves could be called better media.

Based on the above observations, it can be concluded that soil, sand and FYM in the proportion of 1/3 each is an ideal rooting medium for *Albizia lebbeck* seedlings.

CEIBA

Compared to other rooting media, seedlings grown in the medium containing soil, sand and FYM in the proportion of 1:1:1 resulted in significant increase in the height, root length, collar girth, number of functional leaves and biomass accumulation of *Ceiba pentandra* seedlings at various stages of growth.

Among the treatments soil, sand and FYM (1/3) each produced significantly high values in both shoot and root nitrogen content. Cizkova (1981) while conducting a study of some forest trees found that the seedling growth and chlorophyll content were significantly increased with high nitrogen content.

Regarding nutrient uptake also soil 1/3, sand 1/3 and FYM 1/3 proved to be the best medium with respect to N, P and K uptake.

When the nutrient status of the media tested at the end experiment, it was found that soil, sand and FYM 1/3 each was the richest medium.

Leaf tissues from seedlings grown in the media containing soil, sand and FYM in the proportion of 1/3 each exhibited a high relative water content.

The total chlorophyll content of leaves was found to be positively influenced by soil (1/2), sand (1/3) and neem cake (1/6). The nitrogen content of this medium was also found to be high and this is in accordance with Cizkova's (1981) findings.

Different media expressed their efficiency in terms of the number of leaves. In the present study it was found that soil (1/2), sand (1/3) and FYM (1/6) was the best medium when the leaf area of the seedlings was considered.

While considering the over all growth, it can be concluded that to obtain good quality seedlings of *Ceiba pentandra* with increased height, better collar diameter, nutrient uptake and more number of functional leaves it is essential to sow the seeds in a rooting medium containing FYM with equal proportion of sand and soil.

DALBERGIA

The medium which favourably influenced the height of shoots, leaf number, collar girth, root weight and root : shoot ratio of *Dalbergia* seedlings was soil (1/2) + sand (1/3) + neem cake (1/6).

Population count was more in the media soil 1/2 + sand 1/2.

Regarding tissue nutrient concentration, the highest N content was shown by seedlings grown in soil 1/2, sand 1/3 and neem cake 1/6 at 270 DAS. Phosphorus and potassium concentration were more in the media containing soil, sand and FYM 1/3 each followed by soil (1/2), sand (1/3) and neem cake (1/6).

Relatively high content of organic carbon, total N and available P was recorded by soil 1/2, sand 1/3 and FYM 1/6. With respect to available K, soil 1/2, sand 1/3 and neem cake 1/6 recorded the highest concentration.

Though there was no significant difference on total chlorophyll content of the seedlings by the media, soil 1/2, sand 1/3 and neem cake 1/6 resulted in a relatively high chlorophyll 'a' content. In the case of relative water content, soil, sand and FYM 1/3 each and soil 1/2, sand 1/3 and neem cake 1/6 had a similar response.

Regarding the leaf area seedlings of the medium that grown in soil (1/2), sand (1/3) and FYM (1/3) produced the largest leaf area.

Nutrient upake was maximum from the media soil 1/2, sand 1/3 and neem cake 1/6 at 180 DAS.

In essence, the uptake of a nutrient is described by the product of concentration of the nutrient in the soil solution and the absorbing capacity of the root and relative growth rate (Alan Wild, 1989). Data on nutrient uptake indicated the superioriority of soil, sand, neem cake medium for the growth of Dalbergia seedlings.

From the present study it can be inferred that soil 1/2, sand 1/3 and neem cake 1/6 is a better medium for Dalbergia seedlings. Soil 1/3, sand 1/3 and FYM 1/3 was also a favourable medium for this species.

HOPEA

The analysis of the results showed that both in the biometric expression and biomass production, the rooting media containing soil, sand and FYM in the ratio of 1:1:1 outdid all other treatments in the case of Hopea seedlings.

Population count was more in the media soil (1/2) and sand (1/2).

Gupta *et al.* (1975) had recommended sand as an ideal germination medium for large seeds of some common Indian tree species.

Regarding tissue nutrient concentration, soil 1/2, sand 1/3 and FYM 1/6 resulted in high content of N in the shoot. Considering the P concentration of different media soil 1/2, sand 1/3 and neem cake 1/6 continued to be the best at all stages. Plants grown in soil 1/3, sand 1/3 and FYM 1/3 recorded the highest K content at all stages of observation. In the case of root also, a similar trend was seen.

With regard to organic carbon percentage, the highest value was recorded by soil 1/3, sand 1/3 and FYM 1/3. A similar distribution pattern was seen in the case of N also. The differences among the rooting media were statistically nonsignificant in respect of both total and available phosphorus. In the case of available K, no definite trend could be seen. Highest K content was shown by soil 1/2, sand 1/3 and neem cake 1/6 followed by soil 1/3, sand 1/3 and FYM 1/3.

Highest relative water content was recorded by the seedlings grown in soil (1/2), sand (1/3) and FYM (1/6), followed by soil 1/3, sand 1/3 and FYM 1/3.

The chlorophyll content of leaves was not significantly influenced by the rooting media. Sun (1987) proved that in *Acacia confusa* lack of chlorophyll 'b', resulted in a lower ability to absorb light which resulted in reduced photosynthetic capacity and growth. Chlorophyll 'b' was found highest in the seedlings grown in soil 1/2, sand 1/3 and neem cake 1/6.

The highest leaf area was shown by plants grown in soil 1/2, sand 1/3 and neem cake 1/6.

Based on the analysis of data, the media recommended for *Hopea parviflora* seedlings is an equal proportion of soil, sand and FYM. Presence of sand improves drainage and aeration and the addition of cowdung is adviced since it improves moisture retention capacity and fertility.

SANDAL

Data related to growth characters and dry matter accumulation of *Santalum album* seedlings at different stages of growth as affected by different rooting media showed that a medium containing soil, sand and FYM in the proportion of 1/3 each was better compared to other three rooting media tried.

Regarding tissue nutrient concentration N and P were found higher in the medium of soil, sand and FYM (1/3) each. Observations recorded at all stages revealed that soil 1/2, sand 1/3 and neem cake 1/6 is the best medium with respect to K concentration in sandal seedlings. The next best treatment was soil 1/3, sand 1/3 and FYM 1/3.

Regarding the content of organic carbon, total and available N and total

K, the superior media was soil 1/2, sand 1/3 and FYM 1/6. Total and available P was highest in soil 1/3 : sand 1/3 : FYM 1/3. Available K was found to be more in the medium soil 1/2, sand 1/3 and neem cake 1/6.

With regard to relative water content the best medium was soil, sand and FYM 1/3 each. High chlorophyll 'b' content was seen with the media soil, sand and FYM 1/3 each. Maximum leaf area was recorded with plants grown in soil (1/2), sand (1/3) and FYM (1/6).

Uptake of nutrients was more from the medium soil, sand and FYM 1/3 each.

TEAK

The teak seedlings grown in soil, sand and FYM 1/3 each showed higher values for biomass as well as for biometric characters when compared to other media. This along with chemical analytical data confirms the superiority of the medium viz., soil + sand + FYM in the proporption of 1/3 each.

With regard to tissue nitrogen concentration, soil 1/3, sand 1/3 and FYM 1/3 recorded the highest percentage both in the above and underground portion of plants. This was true with respect to phosphorus and potassium content also.

Considering soil nutrient status, soil, sand and FYM 1/3 each was rich in organic carbon, nitrogen and phosphorus. Available potassium content was found more in the medium of soil 1/2, sand 1/3 and neem cake 1/6.

The relative water content was found more in the seedlings grown in the medium of soil 1/2, sand 1/3 and neem cake 1/6. The highest leaf area was recorded by plants grown in the medium, soil, sand and FYM 1/3 each. Uptake studies also reveal that at all stages of seedlings growth the N, P and K uptake was more from the media soil 1/3, sand 1/3 and FYM 1/3.

The teak seedlings grown in the medium of soil, sand and FYM 1/3 each were found superior to other treatments regarding growth and observation characteristics of nutrients.

Summary and Conclusion

SUMMARY AND CONCLUSION

Tropical forests, the reservoir of vast biological diversity, are being destroyed at an alarming rate. Whatever forests are being left today, are under an enormous biotic pressure. There is an urgent need to afforest vast areas with a view to meet our various energy needs and to conserve the ecosystem. Production of large number of quality seedlings is an urgent need for the large scale afforestation and reforestation programmes being under taken. Without knowing the beneficial effects of various media on the growth performance of tree seedlings, most of our farmers are still following the traditional methods of raising the seedlings in ordinary soil available. Information about the influence of the media on growth and vigour of tree seedlings is absolutely essential for large scale production of healthy seedlings in the nursery. In this context, two sets of experiments were conducted at the Instructional Farm, Colege of Horticulture, Vellanikkara with an objective of standardisation of the most suitable media and to elucidate the potential beneficial effects of various rooting media on the growth of tree species in the nursery for agroforestry planting. In the first experiment, eight rooting media were tried on seven tree species and in the second experiment four rooting media were tried on six tree species. The design of the experiment was Randomised Block Design (split plot) with three replications. The rooting medium consisted of the mainplots and species used consisted of the sub plots.

The biometric observations and some physiological parameters in addition to the chemical properties of soil and plants were recorded. Based on the availability and absorption of nutrients by the plants, rooting media were fixed for each species.

The rooting medium containing soil, sand and FYM in the proportion of 1/3 each was the top ranking medium in respect of growth characteristics, biomass accumulation, leaf area, nutrient uptake and the physiological parameters like relative water content and chlorophyll content of majority of the tree species. These species include, *Ailanthus triphysa, Albizia falcataria, Albizia lebbeck, Casuarina equisetifolia, Ceiba pentandra, Gmelina alborea, Hopea parviflora, Santalum album, Swietenea macrophylla* and *Tectona grandis*.

For *Vateria indica*, soil 1/3, sand 1/3 and saw dust 1/3 was found good and for *Dalbergia latifolia*, the superior medium was soil 1/2, sand 1/3 and neem cake 1/6.

Soil as a medium was found to be inferior in general.

A one-to-one correspondence between nutrient accumulation and biomass production could not be observed because of wide variations in elemental concentrations among species. Far better collar girth and dry matter accumulation was observed in treatments with FYM than those without FYM. It is also noted that there exists a positive relationship between leaf area and overall plant growth rate. The lower nutrient content of the media, soil, sand and FYM in the ratio of 1:1:1 at different stages shows the better nutrient export from the site as reflected by high vegetative growth of the seedlings.

The development and activity of various Rhizosphere microflora in the media as well as their effect on the rooting needs to be studied in detail.

For a better understanding of the root activity pattern, radio tracer studies can also be undertaken.

References

REFERENCES

Abdulbari, P.A. and Prasad, K.G. 1987. Growth of tropical pines in Tamil Nadu in relations to soil properties. *Indian For.* 113(1):53-59

Adams, M.A. and Attiwill, P.M. 1984. Role of Acacia species in nutrient balance and cycling. *Aust. J. Bot.* 32(3):205-215

Aguiar, I.B., De and Monogios, G.M. 1988. Effects of vermiculite based substrates on *Eucalyptus citriodora* seedling production of styrofoam trays. *Cientifica* 16(1):133-140

Alan Wild. 1989. Soil condition and plant growth. English Language Book Society/ Long man, Avois, Great Britain, p.991

* Anonymous. 1989. Occassional technical and Scientific notes : Results of media trials using saw dust on germination of *Acacia mangium*. Forest Research Centre, P.O. Box 311, Sandakam 7, Sabah

* Anonymous. 1989. The effect of rooting media on the early growth of three fuel wood species in the nursery. Sri Lanka Forester 19(1-2):41-45

Bahuguna, V.K., Maithani, G.P., Dhaundiyal, U.D. and Unnikrishnan, K.P. 1987. Standardisation of nursery techniques of *Acacia albida* under north Indian moist climatic condition. *Indian For.* 113(2):95-100

Bahuguna, V.K. and Pyarelal. 1993a. Introduction trials of *Acacia caven* at nursery stage germination behaviour of growth of seedling under Deheradun condition. *Indian For.* 119(11):905-910

Bahuguna, V.K. and Pyarelal. 1993b. Standardization of nursery techniques of *Acacia auriculoformis*, *A.* Cumn. ex. Benth under Dehradun conditions. *Indian For.* 119(3):211-216

Banerjee, B., Aparajita Nandi, Nath, S. and Banerjee, S.K. 1986. Characteristics of the soil supporting quality class I. *Eucalyptus tereticornis* in South Bengal. *Indian For.* 112(9):762-771

Barret, R.L. 1983. Raising pines in plantes flats. *South African Forestry Journal* (125):56-67

* Barrs, H.D. and Weatherley, P.E. 1962. A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Aust. J. Biol. Sci.*, 15:413-428

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

Bhardwaj, S., Shamet, G.S., Chauhan, P.S. and Mishra, V.K. 1986. Nursery and plantation technology of chir (*Pinus roxburghii* Sargent) under Solan condition of Himachal Pradesh. *Himachal J. Agric. Res.* 12(1):15-21

* Buresti, E. 1986. Production of large sized planting stock. Annalidell' Istituto Sperimentale per la Selvicoltura 17:141-168

Casarin, V., Aguiar, I.B. DE and Vitti, G.C. 1989. Use of residues of the sugarcane industry in the composition of substrate for the production of *Eucalyptus citriodora* seedlings. *Cientifica* 17(1):63-72

Chang, C., Cline, R.A. and Rinker, D.L. 1987. Spent mushroom compost and paper mill sludge as soil amendments for containerised nursery crops. Combined proceedings, *International Plant Propagators. Society* 37:347-353

* Cizkoa, R. 1987. Sensitivity of Norway Spruce (*Picea abies*) and Swiss mountain pine (*Pinus mugo*) to the acidity of root medium. *Lesnictivi* 35(9):787-798

* Daryono, H. 1982. Effects of soil texture on the growth of seedlings of some fast growing species. Laporan, *Balai Penelitian Hutan* (391):27

* Daryono, H. 1988. Effects of soil type and hot water treatment of seeds on germination and seedling growth in *Acacia mangium. Buletin Penelitian Hutan* 496:17-30

Dhar, D.W., Singh, D.P., Meshram, S.U. and Wats, P.N. 1992. Nursery practices for raising *Leucaena* seedlings. *Indian J. For.* 15(1):71-72

Donald, D.G.M. and Visser, L.B. 1989. Vemicompost as a possible growth medium for the production of commercial forest nursery stock. *Applied Plant Science* 3(2):110-113

Eusebio, M.A., Pacho, M.V., Cornejo, A.T. and Quimio, M.J. JR. 1984. The fertilizing value of saw dust composed with a brown rot fungus (*Lenzites striata* Swartx ex Fries). *Sylvatrop* 9(3-4):101-140

FAO. 1992. Forestry research in the Asia - Pacific, FORSPA publication, Bangkok. No.1. 54 p.

* Ferda, J. and Havelka, F. 1982. Utilization of bark for the mainufacture of growing media. Res. Inst. Soil Improvement, Prague (1):115-124

* Freitas, J.R.De., Martins, F.C.G., Fernandes, O.K., Saito, S.M.T., Rischel, A.P. and Gonclaves, A.N. 1980. Application of organic matter, vermiculite and inoculation of *Rhizobium spp*. in seedlings of *Erythrina falcata. Instituo de Pesquisas Estudos Florestais* 9(20):101-113

Garcia, P.R., Caslillo-Borboran, L. and Dionglay, M.G. 1983. Germination of narig and red lauan (*Shorea negrosensis* Foxw.) seeds in various media. *Sylvatrop* 8(2-4):133-137

* Girouand, R.M. 1983. Propagation of balsamfir by stem cuttings. Information Report, Lourentian Forest Research Centre, Canada (LAU-x-61):14

Gupta, G.N. 1992. Influence of different soil mixtures on nursery growth of some arid zone tree species. *Indian For.* 118(12):952-960

Hamzali, A., Mohd. Abendi Hussain, Mohd. Jaffar Sharri. 1995. A note on the germination of *Dryobalanops aromatica* and shorea macroptera in different media. *J. Trop. For. Sci.* 7(3):507-510

Hassan, M.M. and Dey, H.B. 1979. Studies on the nutritional requirements of forest trees - optimum NPK doses for teak seedlings. *Bano Biggyan Patrika* 8(1-2):57-63

Hazara, C.R. and Tripathi, S.B. 1986. Soil properties, micrometereological para meters, forage yield and phosphorus uptake of berseem as influenced by phosphorus application under Agroforestry system of production. *J. Agron. Crop Sci.* **156**:145-152

* Hendromono. 1988. Improvement of growth and quality of *Acacia mangium* seedlings by using several types of medium. *Bulletin Penelitian Hutan* (502):17-26

* Igaunis, G.A. 1984. Substrates for raising seedlings of introduced woody species in polyethylene green house. *Byulleten' Glavnogo Bolanicheskogo Sada* (130):29-34

Jackson, M.L. 1958. *Soil Chemical Analysis*, Asia Publishing House, New Delhi, pp.498

Kozlowski, T.T. 1982. Water supply and tree growth, Part I - water deficits. *For Abstr.* **43**:57-95

* Langerud, B.R. and Sandvik, M. 1987. Different growth media evaluated in commercial production systems. Rapport, Norsk Institutt for Skogforskining. 18.

* Langerud, B.R. and Sandvik, M. 1988. Physical conditions in peat/perlite mixtures subjected to different irrigation systems. *Acta Horticulturae* (221):363-370

Lo, L.F., Chen, Y.D., Chao, K.M., Zhang, J.H. and Ren, C.C. 1981. Effects of container on growth of larch seedlings. *J. North Eastern For. Institute* (1):58-66

Maithani, G.P., Bahuguna, V.K. and Singh, H.P. 1988. Effect of size of containers and different soil media on the germination behaviour and growth of seedlings of *Acacia nilotica, Albizia procera* and *Dalbergia sissoo. Indian J. For.* **11**(1):56-59

* Marques, L.C.T. and Yared, J.A.G. 1984. Nursery growth of *Didymopanax morototoni* (morototo) seedlings in different soil mixtures. *Bulletin de Pesquisa, Centro de Pesquisa.* Agropecuaria do Tropico Umido, EMBRABA, Brazil (57):16

Martin, C.A., Ponder, H.G. and Gilliam, C.H. 1988. Effects of irrigation rate and media type on growth of *Acer rubrum* L. Res. Report Series - Alabama Agricultural Experiment Station, Auburn University.

* Mateja, L. and Gorzelak, A. 1983. Comparative trials of different containers and substrates for raising seedlings using *Picea pungens* as a test species. Prace Instytutu Badawczego Lesnictwa, Poland (621/625):85-99

McConnel, D.B. 1988. Container size and potting medium affect growth rate of weeping fig and loquat. *Proceedings of the Florida State Hort. Soc.* **100**:337-339

Misra, K.K., Jaiswal, H.R. 1993. Effects of size of polythene bags and potting mixtures on survival and growth of silver oak (*Grevillea robusta* Parker) seedlings. *Indian For.* **119**(11):941-943

Mohan Kumar, B., Sudhakara, K. and Prasoon Kumar. 1992. Influence of growth medium mineral nutrients and auxin on growth of *Swietenia macrophylla* King and *Dalbergia latifolia* Roxb. seedlings. *J. Tree Sci.* **11**(1):44-48

Mohan, S., Prasad, K.G. and Gupta, G.N. 1990. Fertilizer response of selected social forestry species under varying soil texture. *Indian For.* **116**(1):49-57

* Msanga, H.P. and Shehaghilo, I.M. 1980. A preliminary investigation into yellowing in *Pinus caribea* morelet seedlings at Lushoto nursery, Tanszania. Tanszania Silviculture Research Note (36):7

NRCAF. 1991. *National Research Centre for Agroforestry*, Annual Report 1990-91, NRCAF, Jhansi, India, 64 p.

* Papp, L. 1981. Growing medium from pine needles. *Termesztokozegfenyotubol Erdo* **30**(2):63-65

* Pawuk, W.H. 1981. Potting media affect growth and disease in development of containers grown southern pines. Research Note, Southern Forest Experiment Station, USDA Forest Service (SO-268):4

* Phillion, B.J., Dewitt, J. and Bunting, W.R. 1982. Addition of field soil to peat/vermiculite growing media. Nursery Notes, Ministry of Natural Resources, Ontario. (81):3

Poole, R.T. and Conover, C.A. 1985. Growth of *Ficus benjamina* in combinations of peat, sand and melaleuca. *Hort.Sci.* 20(3):383-385

Ramcharan, C. and Gerber, J.M. 1982. Potential use of crushed fruit shells of West Indian Mahagony as a potting media ingredient. *Tree Planters' Notes* 33(4):28-31

Rangaswamy, C.R., Jain, S.H. and Sharma, C.R. 1990. Effect of inorganic fertilizers on seedlings of casuarina, sandal and teak. *My Forest* 26(4):323-326

Rimando, R.M. 1981. Growth and development of some fuel wood species in different potting media. *Sylvatop* 3:91-100

Rimando, R.M. 1987. Soil amendment with perlite. *Canopy Int.* 13(6):9

* Simpson, D.G. 1985. Growing conifer seedlings in wood waste sewage sludge compost. Research note, British Columbia Ministry of Forests (98):18

Singh, R.V. and Sharma, K.C. 1983. Effect of soil and humus mix on the growth of container grown spruce and silver fir plants. *Indian For.* 109(4):193-197

Skolmen, R.G. and Roo, D.S. 1986. Home made potting mixtures for container planting in the Pacific Island. *Tree Planters Notes* 37(4):12-16

* Skoupy, J. 1980. Utilization of waste materials in substrates for growing seedlings: Sbornik vedeckeho Lesnickeho Ustavu Vysoke Skoly Zemedelske V Praze 28:13-37

Starner, W.J. and Hardley, H.H. 1967. Chlorophyll content of various strains of soyabeans. *Crop Sci.*, 5:9-11

Subbiah, B.V. and Asija, G.L.A. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* 25:259-260

* Suhaendi, H. 1986. The effect of NPK fertilizer and mixtures of red yellow podzolic soil and organic matter on the growth of *Pinus merkusil* seedlings in various sizes of plastic bag. *Bulletin Penelitian Hutan* (481):8-26

Tripathi, J.R. and Bajpai, S.P. 1984. Influence of various potting media on the growth of *Anogeissus pendula* (Edgew) seedlings. *Indian J. For.* 7(2):138-140

Ward, T.M., Donnelly, J.R. and Carl, C.M.J.R. 1981. The effects of containers and media on sugar maple seedling growth. *Tree Planters' Notes* 32(3):15-17

Watanabe, F.S. and Olsen, S.R. 1965. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. *Proc. Soil Sci. Soc. Am.* 29:677-678

Watson, D.J. 1952. The physiological basis of variation in yield. *Adv. Agron.* 4:101-145

* Widiarti, A. 1989. Effect of host plants and potting media on the growth of sandal (*Santalam album*) seedlings in the nursery. *Buletin Penelitian Hutan* 1(507):1-11

Worrall, R.J. 1982. Transplanting container - grown plants into the field. Combined proceedings, International Plant Propagators' Society. 32:152-155

* Xie, H.F. and He, Q.Z. 1985. Non soil transplant is a new technique of cultivating good seedlings. *J. North-Eastern For. College*, China. 13(2):35-41

* Yadev, G.S. and Goswami, B.C. 1990. Studies on different rooting media on vegetative propagation of Som (*Persea bombycina*). *Kustern Banko Janakari*. 2(3):272-274

Yadav, A.S., Khare, P.K. and Mishra, G.P. 1982. Growth performance of *Tectona grandis* (L) seedlings in different pot culture media. *Indian J. For.* 5(2):86-89

Zech, W. and Dreschsel, P. 1991. Relationships between growth, mineral nutrition site factors of teak plantations in the rain forest zone of Liberia. *For. Ecol. Manage.* **41**:221-225

Zhou, S.L. 1988. Researches on nursery practice in a newly filled subsiding area of coal mines. *For. Sci. Tech.* 413-16

* Originals not seen

STANDARDISATION OF ROOTING MEDIA FOR SELECTED TREE CROP SEEDLINGS WITH SPECIAL REFERENCE TO PLANT NUTRIENTS

By

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ABSTRACT OF THESIS

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ABSTRACT

A randomized block design (split plot) experiment involving twelve important tree crop seedlings (*Ailanthus triphysa, Albizia falcataria, Albizia lebbeck, Casuarina equisetifolia, Ceiba pentandra, Dalbergia latifolia, Gmelina alborea, Hopea parviflora, Santalum album, Swietenea macrophylla, Tectona grandis* and *Vateria indica*) was conducted in the Instructional Farm, College of Horticulture, Vellanikkara, Kerala Agricultural University, with an objective of standardising the most suitable rooting media for the best growth of above tree seedlings in the nursery for agroforestry planting.

In this study altogether twelve different media were tried, considering their relative cheapness, easy availability and more or less satisfying the desired qualities of an ideal rooting medium.

The results showed that the rooting medium containing soil, sand and FYM in the ratio of 1:1:1 was ideal for all the species except for Dalbergia and Vateria. For Dalbergia, the best medium found was soil 1/2, sand 1/3 and neem cake 1/6 and for Vateria it was soil 1/3, sand 1/3 and saw dust 1/3.