The Status of Firewood in India

L.P.Swaminathan and S. Varadharaj
Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India

Abstract

This paper deals about the status of firewood in India. The firewood is supplied by two sources viz. forest and non-forest areas. The former was estimated to contribute as much as 51 per cent of the total firewood supply. Much of the firewood, removed from forests were unrecorded. In rural areas, non-commercial fuel (firewood, crop residues, cow dung, etc) is still playing and will play an important role in meeting the energy requirements of the people for heating and cooking purposes. Firewood dominates the scene (61.5per cent). The major firewood species in India are *Acacia* spp, *Prosopis* spp, *Eucalyptus* spp, *Tamarindus* spp, *and Casuarina* spp. The main objectives of this paper are i) to study the trends in production of firewood, ii) to assess the demand and supply of firewood and iii) to study the factors responsible for quantity of firewood consumption. The requirement of firewood also significantly varies directly with size of population, per capita income, and forest cover and cattle population. The dependence of population (rural and urban) on forests for firewood is not the same and varied considerably from each other. Though the cattle population shows an increasing trend, the availability of cow dung for fuel is not increasing. The cow dung is being used as manure for agricultural purposes. There would be a more pressure on forest for grazing. This leads to further reduction in forest for the future .The forest cover over the years shows a declining trend. The firewood production in India during 1970 to 1998 showed a positive trend (2.02 per cent of compound growth rate). Although production showed a positive trend, the mean annual production of firewood was 211 million cubic meters (cum), but the mean annual demand was 212.00 million cubic meters. The total annual demand for both rural and urban population is expected to increase from 274.34 million cubic meter to 347.93 million cubic meter by the year 1998 to 2010 AD. The firewood shortage could be fulfilled by artificial plantation on degraded lands (26.7 million hectares). Firewood could also be produced nearer to the consumption centers to reduce the firewood waste and the transport cost. Thus, firewood farming should be developed as a business enterprise to meet the expected shortage in supply of firewood in India.

Keywords: Fire wood, Demand, Supply, Imbalance

Introduction

India has an agriculture-dominant economy. About 43 per cent of land is devoted to agriculture, but the productivity is far below compared to developed countries. About 23 per cent of land area are forest with productivity less than one cubic meter pre ha per year against a potential of 8 to 10 cu m per ha of per year. This same area feeds 100 crores people at present. Forest over in India is not uniformly distributed and the type of forests varies widely. The forests do not only provide timber, fodder and food, but also provide firewood to rural people. India is a rural based economy, with 6.7 lakh villages and thousands of large cities. Both rural and urban populations are heavily dependent on firewood for their fuel requirements. The major sources of biomass energy in India are firewood, agricultural waste and animal dung. Among these, firewood plays a vital role in the economy of rural India since this is the only energy source for domestic purposes. Parts of the urban population still relay on firewood, since the urban poor cannot afford the more costly energy source. The firewood comes from distant hills or other distant places. With transport costs rising, those depending on firewood are finding it difficult purchase firewood.

The household sector is the largest consumer of energy, accounting for about 50 per cent of the total energy consumption. Firewood is the most important form of household energy in both rural and urban areas (mostly poor people) and represents about 90 per cent of the total demand for wood.

The forests, situated in and around villages, are destroyed due to the harvesting of firewood. Normally, firewood is made available from two sources viz., forest and non-forest sources, but this classification does not seem to be realistic because of a large quantity of firewood is collected from nearby forests by the local

people. Records are not available from such collections. Many poor people, living in and around the forests, depend heavily on firewood and other forest products for their basic needs and subsistence income.

In rural areas, the villagers have collect the fire wood from the government lands and nearby forest areas and from their own lands. Reserved and protected including government unclassified forests are poached for firewood and it is pooled to consumption centers including road side tea shops by the way of head loads, ass loads, trucks and tractors. At times trains too carry firewood.

In rural areas firewood provides 70 per cent of fire for cooking, 5 per cent comes from commercial fuel, and the rest from cow dung and agricultural residues. Only 15 per cent of firewood are purchased and 62 per cent are collected from nearby forest areas and public lands while the remaining 23 per cent are collected from private lands.

Continued use of firewood for a variety of purposes other than household demands also need to be looked into. Small restaurants, industries like bricks and file manufacturing units, sugar tea and handicrafts and religious rituals are some of the major consumers in the urban center. The ever growing scarcities of fire wood coupled with continuous price hike have created a special class of professionals handling the task of collection, transport and marketing of fire wood from forests and non forest areas adding further to resource degradation problem. Although the industry sector, rely on commercial fuel, the domestic and agricultural sectors continue to rely mostly on the so-called non-commercial fuels.

The major fire wood species are Acacia spp (*A. nilotica, A. leucopholea, A. holocercia*), *Prosopis juliflora, Eucalyptus* spp and *Casuarina equisetifolia.* The users based their choices on local availability and calorific value of the tree species.

Requirement of firewood also varies directly with size of population, per-capita income and cattle population. Historically, supply of firewood has been lagging behind demand. This gap is found to be widening further with the continued increase in population and reduction in forest area. Of course, using substitutes like cow dung, crop residues and other wastes, compensate the deficit in fire wood supply. However, such substitution has its limitations given the huge size of the population. Cow dung is to be preserved more for its compost value than for fuel. The main objectives of the study are i) to study the trends in production of fire wood ii) to assess the demand and supply of firewood and iii) to study the factors responsible for quantity of fire wood consumption.

Methodology

In the present study, data on production, imports and exports of firewood were collected from 1970 to 1998 from F.A.O. Year Books of Forest Products. The data on population growth rate, area of forest and cattle population in India were collected from the statistical abstracts of India.

To estimate the growth rate of fire wood production the compound growth function was used. The functional form used is

$$Y = abt$$

$$\text{i.e.,} \quad \log y = \log(a) + t \log(b)$$

where:

Y = production (m. cum)
a = constant
b = (1+r)
r = compound growth rate.
t = time variable in years (1,2,3... 29)

In log form, b was calculated using the formula

$$Log(b) = \frac{(\Sigma t.\ \Sigma logy-(\Sigma t.\Sigma logy)/N}{(\Sigma t2-((\Sigma t)^2)/N}$$

where:

N = Number Of years

The Compound growth rate is given by

(Antilog of logb-1)*100

One of the objectives was to estimate quantity demanded and quantity supplied for fire wood production. In the present study demand refers to the total production plus net exports

i.e., $D = P+(I-E)$

where:

D= demand (m. cum), P = production (m. cum), I = Imports qty (m cum)

The supply refers to the total production.

i.e., $S =(P)$

where:

S = Supply, (m cum)
P = Production (m cum)

The projection was estimated using the formula

$$Dt = X (1+R/100)T$$

where,:

Dt = demand projection in 2010
X = qty. demand at base year (1998)
R = CGR (Compound growth rate)
T = difference between base year & projected year (i.e., 12 year)

Demand and supply of fire wood data have been analyzed by calculating their indices to study the actual gap between demand and supply with respect to 1970 as the base year.

The percentage imbalance of demand and supply of firewood was calculated using formula

$$I = ((St - Dt) /Dt \times 100)$$

where:

Dt = demand of firewood (m cum)
St = Supply of firewood (m cum)

Results and Discussion

Fire wood production

The firewood production comes mostly from the forest areas (51 per cent) while the remaining balance of 49 per cent comes from outside forest areas such as man-made plantation, cultural waste lands and degraded lands (26.7 m ha).

Table 1 shows that fire wood production in India from 1970 to 1998 is increasing (2.02 per cent). The mean annual production of firewood is 211.0 m cu m.

Demand and Supply

Table 1 also shows that the mean annual demand is 212.00 m cu m. It could be seen from the same table that annual demand from rural and urban population is expected to increase from 274.34 m cum. to 347.93 m cu m by the year 1998 to 2010 AD. Nevertheless, the supply is expected to increase from 274.33 to 347.0 m cu m by the year 1998 to 2010 AD. The mean annual demand (212.00 m cu m) exceeds the mean annual production (211.87 m cu m) of firewood.

Demand for firewood has increased over the past few decades due to the rise in population and consumption of firewood. An increase in demand of firewood is expected every year. This is aggravated by the decreasing availability of alternative fuel like animal dung and agricultural residues due to its compost use. The demand of firewood is more in rural areas than in urban areas. The demand for firewood by small hotel restaurants, cottage industries and religious rituals including cremation were 10, 25 and 4-m tons, respectively.

Demand and supply indices

Real comparison of the growth of demand and supply of firewood is by done by taking the demand and supply indices and using the value 100 in 1970 (base year). The results are presented in Table 1. Figure 1 shows the increasing rate in demand of firewood. However, the demand indices shows decreasing trend over the years. The supply of firewood also shows same trend as that of demand.

Supply and demand imbalances

Figure 2 shows that the imbalance percentage between demand and supply is high in the years of 1979 to 1980. Subsequently, the imbalance is reduced. This may due to large afforestation programmes implemented by the various state governments.

Demand function

Demand of firewood has been analyzed with respect to population, per-capita income, cattle stocks and forest areas. For this purpose year, wise data for the period of 1970-98 have been used. The linear regression equation of the form was fitted in the form of

$$Y = a + bx1 + cx2 + dx3 + ex4$$

where:

Y = demand of firewood
x1 = population (million)
x2 = per capita income (Rs.)
x3 = Cattle stocks (Head) (million)
x4 = Forest areas (m ha)

Regression equation form

$$Y = -3.3738+2.7649*x1 + 0.0001*x2 + 0.0134x3 + 0.0397x4 \qquad (R2 = 99.7)$$

It could be been from the regression results that the two variables viz., population and per-capita income were significant at five per cent level and R2 was 99.7. It is logical to expect that the demand for firewood would go up with increase in the size of the population and income. It was mentioned earlier that the production of firewood increases at a rate of 2.02 per cent per annum. Compared with this, the population grew at the rate of nearly 2.11 per cent. It could also seen in the figure 2 that the imbalance between demand and supply is reduced to a minimum. Therefore, it could be concluded that as far as the production of firewood is concerned, not much of scarcity is expected in future if the present level of production is maintained.

Supply function

Supply functional form is given as below

Y = Supply of firewood (m cum)
X1 = Forest cover (m cum)
x2 = Net imports (cum m)

Regression form

$y = -1325.89 + 22.94*x1 + 0.0004x2$

It could be seen from the results of the regression equation that forest cover is significantly influenced by the supply of firewood.

Conclusion

The results of the study showed that the gap between demand and supply of firewood is reduced to a minimum. The increase in production seems to go with increase in population. The effect of future increases in income and on the demand of firewood is difficult to predict. Since the increase in income may result the in increase in demand for more refined fuel such as like LPG, Kerosene, etc. Thus, future plans for afforestation should consider this aspect. Any further shortage of firewood could also be met by artificial plantation on degraded land (26.7 million hectares). Fuelwood could also be produced nearer to the consumption centers to reduce the firewood waste and the transport cost. Thus, firewood farming should be developed as a business enterprise, to meet the expected gap between demand and supply of firewood in India.

References

Chandrakanth. M.G. 1979. Consumption of forest products in India. A quantitative Analysis, Indian Journal of Agrl. Economics, Vol. XXXIV, No. 3, July-Sep.

Chitwadgi, S.S. 1999. Wood for Domestic fuel A crisis, *Indian Forester* Vol 125 No. 1 pp 67-71.

Mahendra, A.K., Rai, M.P. and Ratwat, J.K. 1992. Forest for energy in rural economy. *Indian Forester* Vol 118 No 4 pp 256-259.

Maithani, G.P., Mishra, N.M. and Mahendra, A.K. 1986. Socio-economic factors associated with fuel consumption in rural areas (Village – Karaundi). *Indian Forester* Vol 112 No 9 pp 753-761.

Pradeep Khanna and Mahendra, A.K. 1995. Consumption Behaviour of fuelwood in Gujarat. *Indian Forester* Vol 121 No 2 pp 88-95.

Saxena, N.C. 2000. Research issues in forestry in India. *Indian Journal of Agri. Economics* Vol. 55, No. 3, July-Sept. 2000 pp. 359-381.

Vijay Kumar and Sahay, S.N. 1984. Future of fuelwood in Bihar. *Indian Journal of Agril. Economics* Vol 7 No 1 pp 84-86.

Wood or Char coal – which is better? Unasylva – 157, Vol. 39, 1987/3.

World Bank, 1993. India's policies and issues in forest sector development, Report No: 10965, Washington, D.C., USA.

Table 1. The production demand and supply of firewood in India

Year	Production (m cum)	import quantity (cum)	export quantity (cum)	Demand (m cum)	Demand Indices	Supply (m cum)	Supply Indices
1970	154.99	3,500	100.00	154.99	100.00	154.99	100.00
1971	158.56	3,900	500.00	158.56	102.31	158.56	102.30
1972	162.21	3,900	500.00	162.21	102.30	162.21	102.29
1973	165.91	154.99	100.00	165.92	102.29	165.91	102.24
1974	169.64	158.56	500.00	169.64	102.24	169.64	102.19
1975	173.36	162.21	600.00	173.36	102.19	173.36	102.14
1976	177.07	165.91	200.00	177.07	102.14	177.07	102.09
1977	180.77	169.64	4,100	180.77	102.09	180.77	102.07
1978	184.52	173.36	4,100	184.52	102.07	184.52	102.10
1979	188.38	177.07	4,100	188.40	102.10	188.38	102.13
1980	192.40	180.77	4,100	192.42	102.13	192.40	102.17
1981	196.58	184.52	4,100	196.59	102.17	196.58	102.20
1982	200.91	188.38	4,100	200.92	102.20	200.91	102.22
1983	205.37	192.40	4,100	205.37	102.22	205.37	102.21
1984	209.90	196.58	4,100	209.91	102.21	209.90	102.18
1985	214.48	200.91	4,100	214.49	102.18	214.48	102.16
1986	219.11	205.37	4,100	219.11	102.16	219.11	102.13
1987	223.77	209.90	4,100	223.78	102.13	223.77	102.09
1988	228.44	214.48	4,100	228.44	102.09	228.44	102.03
1989	233.07	219.11	4,100	233.07	102.03	233.07	101.96
1990	237.63	223.77	4,100	237.63	101.96	237.63	101.96
1991	242.28	228.44	4,100	242.29	101.96	242.28	101.92
1992	246.93	233.07	899.00	246.94	101.92	246.93	101.88
1993	251.57	237.63	899.00	251.57	101.88	251.57	101.83
1994	256.18	242.28	899.00	256.19	101.83	256.18	101.79
1995	260.77	246.93	899.00	260.77	101.79	260.77	101.75
1996	265.33	251.57	500.00	265.33	101.75	265.33	101.71
1997	269.86	256.18	500.00	269.86	101.71	269.86	101.66
1998	274.33	260.77	500.00	274.33	101.66	274.33	101.66

(For missing data, the data for the previous year have been used)

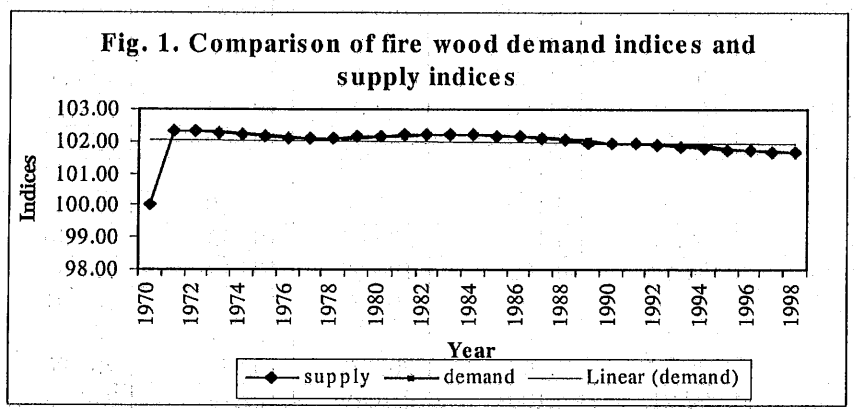
Fig. 1. Comparison of fire wood demand indices and supply indices
Indices
103.00
102.00
101.00
100.00
99.00
98.00
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
supply
demand
Linear (demand)

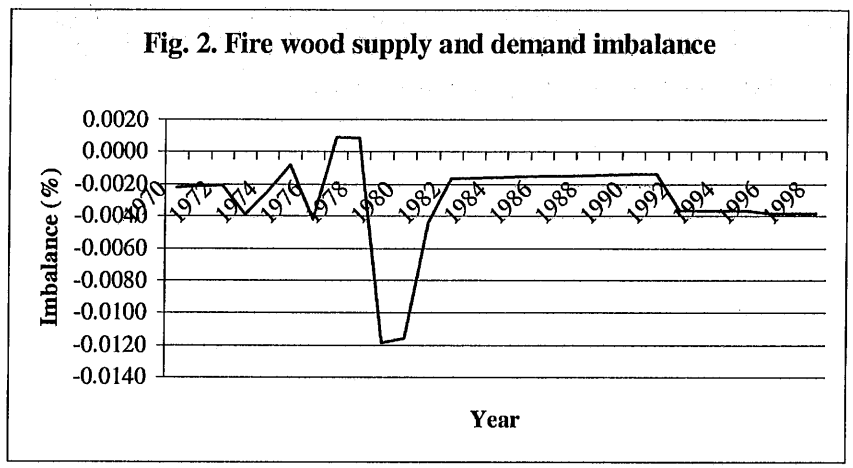
Fig. 2. Fire wood supply and demand imbalance
Imbalance (%)
0.0020
0.0000
-0.0020
-0.0040
-0.0060
-0.0080
-0.0100
-0.0120
-0.0140
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year

Biotechnology of Siberian Pine (*Pinus sibirica*) Seeds

Tret'yakova I. and Novoselova N.
V.N. Sukachev Institute of Forest Russian Academy of Science, Siberian Branch, Institute of Forest, Akademgorodok, Krasnoyarsk 660036, Russia
E-mail: institute@forest.akadem.ru

The ovule of Siberian pine, the main forest forming species in the South Siberia Mountains develops over 16 months. A one- year period spans between pollination to fertilization. The seeds are ripe 2,5 months after fertilization in late August. However, the ripe seeds of Siberian pine have, as a rule, 2 or 4 aborted embryos which take from 1/3 (embryo length is 3-5 mm) to 3/4 (embryo length is 6-9 mm) of an embryonal channel. Seeds of Siberian pine can vary in sizes: large seeds (length is 11- 14 mm), medium – (length is 9 –10mm), small (length is 7- 8 mm) and very small (length of less than 6 mm).

The X-ray data of A.I.Iroshnikov classified the Siberian pine seeds into five categories depending on the degree of embryo development. The classification considered embryo form, defects in the embryo and endosperm (dark spots and constrictions). The following seed categories were distinguished: I – the embryo takes up most of the seed; II – an embryo with deformations (constrictions); III – an embryo taking up 0.3-0.6 of the embryo channel in diameter ("dystrophic"); IV– an embryo with a diameter similar to III group, with constrictions; V – damaged endosperm.

Histochemical analysis of seeds in each category has shown that the viable Siberian pine seeds have a clearly stained embryo with no dark spots and stripes. Such embryos take more than ¼ of an embryo channel. They have a clear inner differentiation at the two polar meristems. Seeds with constrictions on the embryo (Seed category I) and bends of the embryo (Seed category IV) are also related to viability. Seeds with embryos less than 2 mm (embryos are in the form of a point) made up the group of nonviable seeds. Root meristems of such seeds are not detected histologically, while the other tissues of the embryo have already formed. The seed staining reaction ran only in the apical meristem. The "dystrophic"seed category consisted of polyembryonal seeds having 2 or 3 embryos in the form of a point in the corrosive cavity as well as embryos with the dark spots in the hypocotyl and radicle. Dystrophic seed were correlated with nonviable seeds. Seeds with amorphous endosperm and embryo are categorized as nonviable seeds. These seeds did not show any stain patterns. Seeds of the V category are those with spots on more than 5-7 mm of their endosperm and are correlated with nonviable seeds.

The X- ray analysis has shown that the very small seed fraction turned out to be fully sterile. Only 12% of the very small seeds had small embryos 1- 3 mm in length.

It was revealed that viability of seeds in the large fraction is somewhat higher than seeds in the medium fraction. The embryo length in seeds of the large fraction, as a rule were 4-7 mm. After 1.5 month of cold stratification, the embryos of 77 % of the large seeds took more than ½ the length of an embryo channel. After three months, the embryo state did not change. After four months of stratification, the intra-seed embryo growth in 33 % of the seeds was completed. The embryo took up the entire embryo channel and the seeds were considered ready to germinate. Similar changes occurred in seeds of the medium fraction. After three months of stratification, embryos in more than half of the seeds (51%) took up ¾ of the embryo channel. After four months of stratification, 17.5 % of seeds were ready to germinate. Defects in large seeds at the end of stratification were less than for medium seeds (27.2 against 38%).

During the process of stratification, the intra-seed growth of an embryo occurs similarly in the large and medium seed fractions (Table 1).

It is known that the small and medium seeds of Siberian pine are formed in high mountains. Such seeds are small and underdeveloped (1- 3 mm). Embryos in such seeds take up ¼ of an embryo channel length. Under the usual cold stratification (four months) the intra-seed growth of these embryos is not complete. In order to germinate the Siberian pine seeds from high mountain regions, the seeds must undergo double stratification (cold, warm and cold again). After two months of cold stratification, the embryos of high mountain seeds reach ½ of the embryo channel length with a length of 4-5 mm. The seeds are then transferred to a

temperature 20- 24°C for one month. During the period of a warm stratification, active mitotic divisions occur in embryos of Siberian pine seeds. This means that cell number increases. After the seeds are placed in the refrigerator and kept there for one to two months, the intra-seed growth of embryos is completed. The seeds are ready for germination.

Embryos of aborted seeds successfully grow in *in vitro* culture. Seeds 3-5 mm in length are sterilized with 3% iodine solution and washed 3 times in sterile distilled water. Embryos are taken from the seed under sterilized conditions. Later they are planted in agar medium MS where the following hormones are added: indole-acetic acid and kinetin (concentration of 0.25mg/l and 0.2 mg/l, respectively). In one day, rapid saturation of embryo cells with nutrients occurs. On the second day, the bursting of seed lobes and enlarging of embryo size by 1.5 times occurs. On the seventh day, the embryo radicle has emerged, hypocotyl virescence was observed, active growth of seed lobes continued, and germinants were formed. Thus, ripening and germinating embryos were achieved after seven days instead of 5 months of stratification.

Ability to grow *in vitro* culture remains even in embryos at early stages of their embryogenesis. Cultivation of ovules *in vitro* at the initial stage of embryo differentiation (embryo length is 0.5- 0.7 mm) has shown that embryogenesis does not stop. Embryo growth occurs continuously for two months. After three months of cultivating (in the early of September) germination of these embryos begins. These embryos are larger visually than embryos from stratified seeds.

This study has shown that large seeds do better than seeds in smaller fractions. To improve the gene pool for Siberian trees, genotypes that produce large seeds will be selected over those that produce seeds in smaller fractions. We have also shown that formation of under-developed embryos is characteristic of Siberian pine seeds. Completion of the intra-seed embryo growth, which occurs during stratification, is needed for seed germination. The intra-seed embryo growth as well as seed germination is greatly accelerated under culture *in vitro* regime.

Table 1. X- ray analysis of Siberian pine seeds of different size.

Seed fraction	Size of embryo taking the length of embryo channel				With no embryo	Empty	Defective	
	<¼	¼ - ½	¾	1			Endosperm	Embryo
	11.9	40.9	25.6	2.6	1.8	2.4	6.8	8.0
	In 1.5 month of stratification							
Large	1.5	28.0	49.0	2.5	2.3	2.2	10.5	4.0
	In 3 month of stratification							
	1.1	24.7	41.6	2.7	2.7	2.5	20.2	4.5
	In 4 month of stratification							
	0	12.0	25.0	33.1	2.7	2.5	20.7	4.0
	12.5	47.8	15.8	0.1	4.6	3.0	3.9	13.3
	In 1.5 month of stratification							
Medium	4.5	32.5	33.0	2.0	3.0	3.0	10.5	11.5
	In 3 month of stratification							
	2.8	15.7	35.3	1.8	5.7	4.5	21.4	12.8
	In 4 month of stratification							
	2.8	9.5	27.3	17.5	4.9	4.0	21.0	13.0
Small	12.0	0	0	0	0	88.0	0	0
Very small	0	0	0	0	0	100	0	0

Use of Botanicals in Improving Tree Seed Germination and Seedling Vigour

K. Vanangamudi[1], G. Mani, R. Umarani, A. Bharathi and V. Manonmani
Department of Seed Science and Technology
Tamil Nadu Agricultural University
Coimbatore – 641 003, Tamil Nadu, India

Abstract

Reports exist in the literature that seed germination and vigour can be improved by treating the seeds with botanicals. Essential oil of *Ocimum sanctum* (Tulsi) has antimicrobial properties (Dey and Choudhuri 1984), and leaf powders of *Albizia amara* (Arappu) has been reported to improve the germination of soybean (Ravichandran 1991). Rhizome powder of *Acorus calamus* (Vasambu), *Curcuma longa* (Turmeric), and various products of *Azadirachta indica* (Neem) have also been reported to have antiinsecticidal properties (George Usher 1984). Neem seeds pelleted with *Albizia amara* leaf powder (250 g/ kg of seeds) germinated better and has high vigour indices even at high levels of salinity (up to 4 EC dSm^{-1}) and sodicity (up to 30% ESP). In *Casuarina equisetifolia*, seeds treated with neem leaf powder had high germination potential and vigour index. Teak drupes coated with *Albizia amara* leaf powder recorded higher germination and seedling vigour than the other treatments.

Keywords : Botanicals, *Albizia amara, Acorus calamus, Curcuma longa, Ocimum sanctum, Azadirachta indica, Casuarina equisetifolia,* antioxidants, germination, vigour index

Introduction

The climatic conditions of India greatly accelerate the seed ageing phenomenon under the ambient storage environment, causing deterioration and loss of viability (Basu 1976). Some reports exist in the literature that the life span of seeds can be enhanced by pre-treating seeds with chemicals such as phenols, salts, organic acids, hormones, and vitamins before storage (Coolbear et al. 1984). Antioxidants (Dey and Jana 1988) and some phytohormones (Leopold and Kriedemann 1975) are thought to have a role in delaying senescence. An essential oil of *Ocimum sanctum* has antimicrobial properties (Dey and Chaudhuri 1984), and leaf powder of *Albizzia amara* has been reported to improve the germination in soybean (Ravichandran 1991).

Rhizome powder of *Acorus calamus* and *Curcuma longa,* and various products of *Azadirachta indica* have also been reported to have antiinsecticidal properties (George Usher 1984). Acetyl salicylic acid is a well-known antioxidant. Impregnation of seeds with iodine vapour and treatment of seeds with halogens have been reported to significantly reduce seed deterioration in many crops (Basu 1993).

The effect of the various seed treatments including both the chemicals and botanicals on seed viability and the biochemical activities involved in the maintenance of the seed vigour are yet to be elucidated.

[1] Author for correspondence

Materials and Methods

Casuarina equisetifolia

Influence of pre-storage treatments on shelf-life of seeds

Fresh seeds were graded with a specific gravity separator (WESTRUP LA-K, No. 89036) at 390-410 rpm with a vertical height, horizontal height, and air below rate adjustments of 2, 0 and 3, respectively. The seeds of first grade class (A) were then subjected to the following dry pre-storage treatments using $CaCO_3$ as the filler @ 3 g/kg.

1. Untreated seeds (control)
2. Halogenation mixture @ 2 g/ kg of seed
3. Neem (*Azadirachta indica*) leaf powder @ 1:20 ratio (Seed: Leaf powder)
4. Turmeric (*Curcuma longa*) rhizome powder @ 2 g/kg of seed
5. Vasambu (*Acorus calamus*) rhizome powder @ 1:20 ratio
6. Acetyl salicilic acid @ 2 mg/kg of seed
7. Arappu (*Albizia amara*) leaf powder @ 1:20 ratio.

The experiment was set up with a Completely Randomized Design (CRD) with four replications.

The halogenation mixture of 1 kg consisted of Iodine (1 g), *Curcuma longa* rhizome powder (2 g), *Albizia amara* leaf powder (2 g), Acetyl salicilic acid (1 g), *Acorus calamus* rhizome powder (1 g), and 993 g of dehydrated $CaCO_3$.

The seeds thus treated were divided into ten parts and sealed in air tight polyethylene bags (700 gauge) in order to facilitate periodic sampling without having to disturb the sealed storage environment. Seed samples were drawn at bimonthly intervals, and the physiological attributes (germination and vigour) and the biochemical parameters (amylase, catalase, peroxidase, superoxide dismutase, ascorbic acid, lipid peroxidation and electrical conductivity) were measured.

Azadirachta indica

Performance of *Albizia amara* leaf powder pelleted neem seeds at different sodicity and salinity levels

Neem seeds pelleted with 200 g of dried arappu leaf powder along with 4 g of thiram using acacia gum as an adhesive @ 300 ml/kg of seed, were tested for performance at different sodicity and salinity levels. The pot culture experiment was conducted using CRD with four replications.

Performance of *Albizia amara* leaf powder pelleted neem seeds under sodicity levels

Soils having different Exchangeable Sodium Percentage (ESP) such as: (1) <15 ESP (Normal soil), (2) 15-30 ESP (Sodicity level 1), and (3) > 30 ESP (Sodicity level II) were collected and used for the pot culture study.

Performance of *Albizia amara* leaf powder pelleted neem seeds under salinity levels

The salinity levels tried were: (1) <1 EC (dSm^{-1}) (normal), (2) 1-3 EC (dSm^{-1}), and (3) 4 EC (dSm^{-1}).

Earthen pots of a uniform size, 30 cm upper diameter, 20 cm lower diameter with a height of 40 cm, were used. The pots were filled with 4 kg of normal soil. The solutions were added daily to the respective pots @ 500 ml/pot. Each treatment contained 2 pots and was replicated four times. Fifty seeds were sown equally in two pots (25 seeds/pot).

The root and shoot length, dry matter production, and leaf chlorophyll contents were recorded at 180 days after sowing.

Tectona grandis

Tectona grandis

Effect of pre-storage treatment with biocides and botanicals on the shelf life of teak drupes

Fresh drupes of the big size class obtained from Top Slip were scarified in commercial grade sulphuric acid (50 ml/100 g of drupes) for 1 hr. The scarified drupes were then coated with the following biocides and botanicals using gum arabica @ 200 ml/100 g of drupes as an adhesive.

1. Uncoated dry seed (Control)
2. Coated with Captan @ 0.4 g/100 g of drupes mixed with filler, chalk powder @ 25 g/100 of drupes
3. Coated with Thiram @ 0.4 g/100 g of drupes mixed with filler, chalk powder @ 25 g/100 g of drupes
4. Coated with Carbaryl @ 0.4 g/100 g of drupes mixed with filler, chalk powder @ 25 g/100 g of drupes
5. Coated with neem (*Azadirachta indica*) oil @ 25 ml/100 g of drupes (adhesive not used for this treatment)
6. Coated with neem leaf powder @ 25 g/100 g of drupes
7. Coated with notchi (*Vitex negundo*) leaf powder @ 25 g/100 g of drupes
8. Coated with arappu (*Albizia amara*) leaf powder @ 25 g/100 g of drupes

After air drying for 1 hr, the pre-treated drupes were packed in 700 gauge thick polyethylene bags and stored under ambient conditions. Seed samples were drawn at 4-month intervals for 24 months. Germination, dry matter production, and vigour index were measured.

The data were statistically analysed as per Panse and Sukhatme (1978).

Results and Discussion

Casuarina equisetifolia

Influence of pre-storage treatments on shelf life of seeds

The results of this study revealed that there was a progressive decline in *C. equisetifolia* seed viability from 41% (initial stage) to 22.3% (nine months). However, the rate of deterioration was faster in the untreated control seeds, which recorded the lowest germination, 15.1%. All the seed treatments recorded higher germination percent compared to control, although the percentage increase varied. It was 56.2, 40.8, 35.2, 34.0, 13.2, and 12.2% for neem, acetyl salicylic acid, arappu, acorus, turmeric, and halogenation, respectively (Table 1).

All treatments were superior to the untreated control seeds for vigour index, although the percentage of increase varied. The neem-treated seeds were superior to the rest of the treatments, and this was followed by acetyl salicylic acid (Table 1).

All the treatments recorded higher enzyme activity than the control. Neem and acetyl salicylic acid treatments were superior to the other treatments. The percent increase over the control recorded at the ninth month of storage was 28.2, 33.0, 53.1 and 22.3 by the neem leaf treated seed, for amylase, catalase, peroxidase, and superoxide dismutase activities, respectively. Acetyl salicylic acid recorded a percent increase of 26.1, 33.0, 25.0, and 18.9, respectively (Tables 1, 2).

The ascorbic acid, which is an endogenous antioxidant and capable of ameliorating the deteriorative changes of senescence, was also found to be profoundly influenced by period of storage and by the treatments imposed on the seeds prior to storage. As observed for the other biochemical attributes, % ascorbic acid also underwent a progressive decline from 34.0 % (initial stage) to 18.71 % (nine months). However, it was found that the magnitude of decrease in the ninth month over the control was very low in seeds treated with neem leaf powder, acetyl salicylic acid, and halogenation when compared with the control (Table 3).

Estimations of lipid peroxidation and electrical conductivity revealed that both the parameters increased progressively with the storage period. However, the percentage of increase was lower in the cases of seeds treated with neem leaf powder and acetyl salicylic acid for lipid peroxidation (43.9%) when compared with the control seeds (54.2%) (Table 3).

With respect to electrical conductivity (dSm^{-1}), neem leaf powder and acetly salicylic acid treated seeds recorded the lowest increase over the initial value (18.1%) during the nine months of storage, whereas the control seed recorded 61.5% increase (Table 3).

In this experiment, the potential of neem leaf powder has been better or equivalent to the antioxidant, acetyl salicylic acid, in controlling the process of seed senescence. These treatments have controlled the deterioration of the endogenous antioxidant, ascorbic acid. The lipid peroxidation process has been reduced. A number of antioxidants and metal chelating agents have been shown to play a significant role in counteracting free radical reaction. Depletion of antioxidants viz., ascorbic acid (Vitamin C) or alpha-tocopherol, means loss of protection; therefore the extent depletion will reflect the nature and degree of damage occurring in the seeds (Hendry 1993).

The longevity of seeds should be favoured by lower overall levels of unsaturated fatty acids and increased levels of antioxidants, such as tocopherols, which would lead to diminished autoxidation and free-radical activity (Ponquett et al. 1992). Thus, the seeds treated with neem leaf powder and acetyl salicylic acid showed superior performance over other seed treatments and controls in germination and seedling vigour.

Azadirachta indica

Performance of *Albizia amara* leaf powder pelleted neem seeds at different sodicity and salinity levels

A general suppression of top growth is probably the most common plant response to salt stress. Plant responses to salt stress and symptoms of injury are highly variable, as has been amply emphasized in the reviews by Bernstein (1975) and Jennings (1976). This variability can be between species (Lessani and Marschner 1978) or even between varieties of the same species (Yeo and Flowers 1982). Cruz et al. (1990) and Caro et al. (1991) found that besides other growth parameters, plant height and number of laterals were useful characters for measuring salinity tolerance. The present study revealed that reduction in neem seedling height in terms of root and shoot length was greater due to an increase in soil salinity (up to 4 dSm^{-1}) and sodicity (up to >30% ESP). The seedlings did not survive in high salinity at 180 days after sowing. The pelleted seeds recorded longer root and shoot length compared to unpelleted seeds under all salinity/sodicity levels (Table 4). The excess chloride ions would probably have interfered with the biosynthesis of plant growth hormones, such as auxins and gibberellins. The excess sodium ions would have made the potassium ions unavailable, resulting in interruption of the transport of photoassimilates for the production of new leaves and branches. Venkatachalam (1983) and Balamohan (1994) reported reduced plant height, number of laterals, and length of roots in susceptible cultivars under increased salinity.

Generally, dry matter production of seedlings was reduced by increasing stress (Saleem et al. 1984). In this study, the seedling dry matter production was affected by salinity and sodicity levels. The dry matter production of seedlings was greatly affected by increasing levels of salinity and sodicity as the growth advanced. Similar findings were reported by several authors (Porath et al. 1972; Balamohan 1994). The seeds pelleted with *Albizia amara* leaf powder recorded higher dry matter production compared to the unpelleted seeds at all stages of growth. Better root systems of the seedlings produced from pelleted seeds would have favoured the synthesis of hormones such as kinetin, which could have transported to the axillary buds for better growth of the plants.

Salt stress impaired the synthesis of green pigments and its components, such as total chlorophyll. Seedlings produced from pelleted seeds recorded higher total chlorophyll content compared to unpelleted seeds sown in saline soil (up to 4 ES dSm^{-1}) and sodic soil (up to 30% ESP) (Table 4). Reddy and Vora (1986) suggested that enhanced chlorophyllase activity reduced the chlorophyll content under high soil salinity in bajra. The total chlorophyll also progressively declined with increasing salinity levels, as reported in several crops (Weinberg 1975; Garg *et al.* 1982).

Tectona grandis

Effect of pre-storage treatment with biocides and botanicals on the shelf life of teak drupe

Tto determine the efficacy of botanicals on improving germination in storage, acid scarified drupes of teak were coated with leaf powders of botanicals viz., neem (*Azadirachta indica*), notchi (*Vitex negundo*), and arappu (*Albizia amara*), as well as a biocides Arappu leaf powder. When tested after 24 months of storage, germination was higher at 50.8% as opposed to 38.4% for the dry seed control. The beneficial effect of

arappu leaf powder in improving the seed germination of annuals has been reported earlier by Angamuthu (1991) and Muruganantham (1995). They ascribed the beneficial effects to the presence of a gibberellin-like substance in addition to saponins and nutrients, especially the micronutrients (zinc), which might have synergistically interacted with the amino acid tryptophan to form indole acetic acid (IAA) (Table 5).

Literature cited

Angamuthu, K., 1991. Studies on seed pelleting, physiological maturity, sowing quality and storage in small millets. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore-641 003.

Balamohan, T.N., 1994. Evaluation of chilli (*Capsicum annum* L.) genotypes under salt affected soils. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore – 641 003.

Basu, R.N., 1976. Physico-chemical control of seed deterioration. *Seed Research,* vol. 4, pp. 15-23.

Basu, R.N., 1993. Seed invigoration for extended storability. *Seed Research,* vol.1, pp. 216.

Bernstein, L., 1975. Effect of salinity and sodicity on plant growth. *Annual Review of Plant Physiology,* vol. 13, pp. 295-312.

Caro, M., Cruz, V, Cuartero, J., Estan, M.T., and Bolarin, M.C., 1991. Salinity tolerance of normal-fruited and cherry tomato cultivars. *Plant and Soil,* vol. 136, pp. 249-255.

Coolbear, P., Francis, A, and Grierson, D., 1984. The effect of low temperature pre-sowing treatment on the germination performance and membrane integrity of artificially aged tomato seeds. *Journal of Experimental Botany,* vol.35, pp. 1609-1617.

Cruz, V., Caurtero, J., Bolarin, M.C., and Romero, M., 1990. Evaluation of characters for ascertaining salt stress responses in *Lycopersicon* species. *Journal of the American Society of Hort. Sci.,* vol. 115, no. 6, pp. 1000-1003.

Dey, B.B., and Choudhuri, M.A., 1984. Essential oil of *Ocimum sanctum* L. and its antimicrobial activity. *Indian Perfumer,* vol. 28, pp. 82-87.

Dey, B.K., and Jana, S., 1988. Effect of antioxidants and dark-induced changes in some biochemical parameters in detached leaves of *Sechium edude* in Darjeeling hills of Eastern Himalayas. *Environ. & Ecol.,* vol.2, pp. 381-385.

Garg, B.K., Kathju, S., Vyas, S.P., and Lahiri, A.N., 1982. Influence of soil fertility on the growth and metabolism of wheat under salt stress. *Biologia Plantarum,* vol. 24, pp. 290-295.

George Usher, 1984. The dictionary of plants used by man. CBS publishers and distributors, New Delhi.

Hendry, G.A.F., 1993. Oxygen free radical processes and seed longevity. *Seed Science Research,* vol.3, pp. 141-153.

Jennings, D.H., 1976. The effects of sodium chloride on higher plants. *Biol. Rev.,* vol. 51, pp. 433-486.

Leopold, A.C., and Kriedemann. P.E., 1975. Plant growth and development, McGraw-Hill, New York.

Lessani, H., and Marschner, H., 1978. Relation between salt tolerance and long distance transport of sodi um and chloride in various crop species. *Australian Journal of Plant Physiology,* vol.5, pp. 27-32.

Muruganantham, 1995. Influence of seed pelletization on viability, vigour and production potential in rice fallow cotton cv. MCU 7. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore-641 003.
Panse, V.G., and Sukhatme, P.V., 1978. Statistical Methods for Agricultural Workers. ICAR., New Delhi, 327 pp.

Ponquett, R.T., Smith, M.T., and Ross, G., 1992. Lipid autoxidation and seed ageing. Putative relationships between seed longevity and lipid stability. *Seed Science Research,* vol.2, pp. 51-54.

Porath, E., Kahana, I., and Poljakoff Mayer, A., 1972. The effect of chloride and sulphate types of salinity on growth and on osmotic adaptation of pea seedlings. *Plant and Soil,* vol.36, pp. 449-459.

Ravichandran, G., 1991. Studies on the pattern of seed deterioration. The performance of differentially aged seeds in the field and the quality of their resultant seeds in maize, groundnut and soybean. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore-641 003.

Reddy, M.P., and Vora, A.B., 1986. Changes in pigment composition, hill reaction activity and saccharids metabolism in Bajra (*Pennisetum typhoides*. H.) leaves under NaCl salinity. *Photosynthetica,* vol.20, pp. 50-55.

Saleem, M., Akbar, M., Aziz, S., and Qudari, M.S., 1984. Physiology of salt tolerance of gram (*Cicer arietinum*). *Journal Agric. Res. Pakistan,* vol.22, no. 4, pp. 317-320.

Venkatachalam, R., 1983. Studies on the biological efficiency of chilli (*Capsium annum* L.) 1. Time of emergence and seedling vigour. *Indian For.,* vol.116, no.7, pp. 568-571.

Weinberg, R., 1975. Effect of growth in highly salinised media on the enzymes of the photosynthetic apparatus in pea seedlings. *Plant Physiology,* vol.56, pp. 8-12.

Yeo, A.R., and Flowers, T.J., 1982. Accumulation and localisation of sodium ions within the shoots of rice (*Oryza sativa* L.) varieties differing in salinity resistance. *Physiologia Plant.,* vol. 56, pp. 343-348.

Table 1. Effect of prestorage treatments on germination, vigour index, and amylase activity of *C. equisetifolia* seeds.

Prestorage treatment (T)	Germination (%)		Vigour index		Amylase activity (units/mg/min)	
	Months of storage (P)					
	0	9	0	9	0	9
Control	41 (39.81)	15.1 (22.87)	192	45	0.870	0.510
Halogenation	41 (39.81)	17.2 (32.84)	192	58	0.870	0.625
Neem (*Azadirachta indica*) leaf powder	41 (39.81)	31.5 (34.147)	192	131	0.870	0.710
Turmeric (*Curcuma longa*) rhizome powder	41 (39.81)	17.4 (24.65)	192	58	0.870	0.625
Acorus (*Acorus calamus*) rhizome powder	41 (39.81)	22.9 (28.59)	192	76	0.870	0.625
Acetyl salicylic acid	41 (39.81)	25.5 (30.33)	192	96	0.870	0.690
Arappu (*Albizia amara*) leaf powder	41 (39.81)	23.3 (28.87)	192	85	0.870	0.690
Mean	41 (39.81)	22.3 (28.23)	192	77	0.870	0.652
	T x P		T x P		T x P	
CD (P=0.05)	3.52		10.55		0.030	

Table 2. Effect of prestorage treatments on catalase activity, peroxide activity, and superoxide dismutase of *C. equisetifolia* seeds.

Prestorage treatment (T)	Catalase activity(units/mg/ minute)		Peroxide activity(OD value)		Super oxide dismutase(units/ mg/minute)	
	Months of storage (P)					
	0	9	0	9	0	9
Control	3.36	1.50	0.090	0.015	4.03	1.63
Halogenation	3.36	1.62	0.090	0.017	4.03	1.71
Neem (*Azadirachta indica*) leaf powder	3.36	2.24	0.090	0.032	4.03	2.10
Turmeric (*Curcuma longa*) rhizome powder	3.36	1.62	0.090	0.017	4.03	1.71
Acorus (*Acorus calamus*) rhizome powder	3.36	1.78	0.090	0.017	4.03	1.86
Acetyl salicylic acid	3.36	2.24	0.090	0.020	4.03	2.01
Arappu (*Albizia amara*) leaf powder	3.36	2.24	0.090	0.020	4.03	2.01
Mean	3.36	1.90	0.090	0.023	4.03	1.86
	T x P		T x P		T x P	
CD (P=0.05)	0.173		0.003		1.23	

Table 3. Effect of prestorage treatments on ascorbic acid, lipid peroxidation, and electrical conductivity (dSm^{-1}) of *C. equisetifolia* seeds.

Prestorage treatment (T)	Ascorbic acid (%)		Lipid peroxidation (OD value)		Electrical conductivity (dSm^{-1})	
	Months of storage (P)					
	0	9	0	9	0	9
Control	34.00	12.75	0.065	0.142	0.090	0.234
Halogenation	34.00	25.50	0.065	0.121	0.090	0.201
Neem (*Azadirachta indica*) leaf powder	34.00	25.50	0.065	0.116	0.090	0.110
Turmeric (*Curcuma longa*) rhizome powder	34.00	14.50	0.065	0.130	0.090	0.200
Acorus (*Acorus calamus*) rhizome powder	34.00	12.75	0.065	0.132	0.090	0.172
Acetyl salicylic acid	34.00	25.50	0.065	0.116	0.090	0.110
Arappu (*Albizia amara*) leaf powder	34.00	14.50	0.065	0.119	0.090	0.171
Mean	34.00	18.71	0.065	0.125	0.090	0.171
	T x P		T x P		T x P	
CD (P=0.05)	2.47		0.003		0.019	

Table 4. Effect of sodicity and salinity levels on root length, shoot length, dry matter production and total chlorophyll of neem after 180 days.

Treatment (T)	Sodicity levels (N)				Salinity levels (N)			
	<15% ESP	15-30% ESP	>30% ESP	Mean	<1EC dSm^{-1}	1-3EC dSm^{-1}	4EC dSm^{-1}	Mean
a. Root length (cm)								
Control	28.5	23.8	16.9	23.1	24.9	22.5	0.0	15.8
Pelleted	30.2	25.8	18.3	24.8	26.7	22.74	0.0	16.5
Mean	29.4	24.8	17.6	23.9	25.8	22.6	0.0	16.2
	T	N	T x N		T	N	T x N	
SEd	0.239	0.293	0.415		1.814	2.222	3.142	
CD (P=0.05)	0.503	0.616	NS		3.953	4.841	NS	
b. Shoot length (cm)								
Control	38.2	27.8	19.4	28.5	35.2	23.4	0.0	29.3
Pelleted	40.5	30.6	24.7	31.9	38.9	24.5	0.0	21.1
Mean	39.4	29.2	22.1	30.2	37.1	24.0	0.0	25.2
	T	N	T x N		T	N	T x N	
SEd	0.165	0.202	0.286		0.152	0.186	0.263	
CD (P=0.05)	0.347	0.425	0.600		0.319	0.391	0.552	
c. Drymatter production (g $seedling^{-1}$)								
Control	8.61	6.70	3.53	6.28	8.0	4.3	0.0	4.1
Pelleted	8.97	7.35	4.10	6.81	9.0	4.7	0.0	4.6
Mean	8.79	7.03	3.82	6.54	8.5	4.5	0.0	4.4
	T	N	T x N		T	N	T x N	
SEd	0.054	0.066	0.093		0.047	0.057	0.081	
CD (P=0.05)	0.112	0.138	NS		0.098	0.120	0.170	
d. Total chlorophyll (a+b) (mg g^{-1} of fresh leaf)								
Control	2.203	1.842	1.639	1.894	2.046	1.759	0.000	1.269
Pelleted	2.429	1.911	1.703	2.014	2.243	1.766	0.000	1.336
Mean	2.316	1.876	1.671	1.954	2.145	1.762	0.000	1.302
	T	N	T x N		T	N	T x N	
SEd	0.020	0.024	0.034		0.047	0.058	0.081	
CD (P=0.05)	0.041	0.051	NS		NS	0.121	NS	

Table 5. Effect of prestorage treatments with biocides and botanicals on germination, dry matter production, and vigour index of teak drupes in storage.

Pre-storage treatment (T)	Germination (%)		Dry matter production (g seedling^{-1})		Vigour index	
	Months of storage (P)					
	0	24	0	24	0	24
Control	22.2 (28.1)	38.4 (38.3)	0.663	0.792	319	458
Captan	22.2 (28.1)	42.4 (40.6)	0.663	0.990	319	794
Thiram	22.2 (28.1)	45.2 (42.2)	0.663	1.187	319	852
Carbaryl	22.2 (28.1)	38.6 (38.4)	0.663	1.072	319	798
Neem oil	22.2 (28.1)	43.8 (41.4)	0.663	0.955	319	867
Neem powder	22.2 (28.1)	45.8 (42.6)	0.663	0.977	319	953
Notchi powder	22.2 (28.1)	46.6 (43.1)	0.663	1.496	319	996
Arappu powder	22.2 (28.1)	50.8 (45.5)	0.663	1.789	319	1120
Mean	22.2 (28.1)	43.9 (41.5)	0.663	1.157	319	855
	T x P		T x P		T x P	
CD (P=0.05)	0.62		0.017		23	

Effect of Seed Source on Tree Seed Germination and Vigour Potential

K. Vanangamudi[1], G. Mani, A. Venkatesh and S. Natarajan
Department of Seed Science and Technology
Tamil Nadu Agricultural University
Coimbatore – 641 003, Tamil Nadu, India

Abstract

A survey was conducted in seven agroclimatic zones of Tamil Nadu, and candidate plus trees of *Acacia nilotica, Albizia lebbeck, and Azadirachta indica* were identified. Seeds obtained from the identified candidate plus trees of different seed sources were observed for variations in seed physiological characteristics under nursery conditions as well as their performance under field conditions. The result indicated that for seed collection, phenotypically superior trees could be identified from Cumbum of Southern zone for *Acacia nilotica*, Anamalai WLS of the Western zone for *Albizia lebbeck*, and E. Kumaralingapuram of the Southern zone for *Azadirachta indica*.

Keywords: *Acacia nilotica, Albizia lebbeck, Azadirachta indica*, seed source, physiological quality.

Introduction

Agroecological conditions largely comprising edaphic and other environmental factors have numerous effects on the performance of seeds. The possibility exists that seeds are also influenced by their place of origin (Heydecker 1972). The use of sound seed from stands of high inherent quality is widely recognized as the best means of ensuring fast growing and healthy plantations capable of yielding high quality wood (Aldhous 1972). The multiplication and distribution of quality seeds or seedlings is of immediate importance to accomplishment breakthroughs in these programmes. For tree planting programmes, abundant quantities of seeds need to be produced, collected and tested for germination and seedling vigour.

Prior to seed testing, seed source variations need to be delineated and identified, as does the best seed source for collection of good quality seeds and subsequent production of high quality planting materials. Variation in seeds has been reported in many tree species. These variations are mainly dictated by environmental factors. Variation may be due to altitudinal differences in yellow poplar (*Populus* sp.) (Barnett and Farmer 1978) or to region of collection (Bonner 1984). Hence, the best seed source has to be selected to screen the natural and environmental variations.

It is essential to evaluate the performance of different seed sources under nursery conditions in order to establish the source effect and for further selection of best-suited sources. Similarly, for field planting, it is also important to know the survival potential of sources (Chauhan and Verma 1993; Indra and Basha 1999). Hence, this study was conducted in order to determine the effect of different seed sources on seed quality and its subsequent impact on seedling growth. This study was conducted to elucidate the seed source variation for babul (Karuvel) (*Acacia nilotica* ssp. *indica*), vagai (*Albizia lebbeck*), and neem (*Azadirachta indica*) in order to determine the best seed source for collection.

Materials and Methods

The seeds of karuvel, neem, and vagai, collected from the identified superior trees from different agroclimatic zones of Tamil Nadu, formed the basic material for the study (Table 1). Physiographic and climatic details are furnished in Table 2.

[1] Author for correspondence

Seed pre-treatments for *Acacia nilotica* and *Albizia lebbeck*

The seeds of *Acacia nilotica* and *Albizia lebbeck* were scarified using commercial grade H_2SO_4 @ 600 ml/Kg of seed for 60 and 25 min, respectively and thoroughly washed in running tap water. Next, the seeds were soaked in cold water for 24 h.

Nursery performance

The pretreated seeds of *A. nilotica* and *A. lebbeck* and untreated seeds of *Azadirachta indica* were sown in polybags (15 x 25 cm size). The potting mixture consists of red soil, sand, and farmyard manure in a proportion of 2:1:1. The experiment was set up in a completely randomized design with four replications of one hundred seeds each. The seedlings were raised as per standard nursery practices. The following growth parameters were observed after six months of sowing:

1) Germination. Twenty-one days after sowing, the number of germinated seedlings was counted, and expressed as a percentage of the total seed sown.

The following growth measurements were assessed on ten randomly selected seedlings six months after sowing.

2) Root length. The seedlings were removed from the polybags without damaging the root and washed thoroughly to remove the adhering soil particles. The root length was measured from the collar region to the tip of the primary root and expressed in cm.

3) Shoot length. The shoot length was measured from the collar region to the growing tip of the seedling and expressed in cm.

4) Shoot collar diameter. The diameter of the shoot at the collar region was measured using a Vernier Caliper and expressed in cm.

5) Dry matter production. The dry matter production was obtained by taking the sum of the root and shoot dry weights and was expressed in g.

Field performance

Six months old seedlings were field planted using a spacing of 3 x 3 m for *A. nilotica* and *A. lebbeck*, and 2 x 2 m for *A. indica* in a randomized block design, replicated two times. The observations of survival percentage, plant height, and shoot collar diameter on five random plants were recorded in each replication 3 months, 12 months, and 16 months after planting.

The data were analyzed statistically by the methods described by Panse and Sukhatme (1978).

Results

Acacia nilotica

Higher seed germination was observed in the *Acacia nilotica* seeds obtained from Tirupattur (95%) and Vellore (92%; Northeastern zone) and Cumbum (91%) and Madurai (90%; Southern zone) (Table 3).

Significant differences were observed among seed sources for shoot length, root length, shoot collar diameter, and dry matter production. The shoot length of the seedlings from Tirupattur (83.0 cm) followed by those from Vellore (82.5 cm) and Salem (81.3 cm) exhibited the best performance at six months after sowing. At six months after sowing, Tirupattur (32.4 cm) followed by Vellore (31.0 cm), Cumbum (29.5 cm), and Madurai (29.0 cm) had the longest root length (Table 3).

Evaluation of seedlings in the field sixteen months after planting showed greater plant height (327.5 cm) and shoot collar diameter (6.0 cm) from those collected from Tirupattur seed source. The Salem seed source had the lowest values, 151.0 cm and 2.2 cm, respectively (Table 4).

Albizia lebbeck

Significant variations among the seed sources were recorded for germination in *Albizia lebbeck*. The highest seed germination was obtained in Tirunelveli (94.0%) and Anamalai WLS (91%) seed sources. They belong to the Southern and Western agroclimatic zones, respectively (Table 5). This suggested that environmental and physiographic conditions played an important role in the survival and establishment of seeds.

The growth performance in the nursery revealed that Coimbatore had the longest root length (49.47cm), followed by Madurai (47.63 cm). The seedlings from Aruppukottai had the longest shoot length (31.57 cm), which was equivalent to those from Salem (31.37 cm). Ramanathapuram seedlings had the shortest shoots at 20.80 cm. For collar diameter, the seedlings from Tirunelveli, Aliyar, and Chenglepet produced the highest value (0.9 cm), while those from Salem had the lowest value (0.5 cm). The average total dry weight was 9.78 g/seedling. The Tirunelveli seed source had the highest dry weight (13.02 g/seedling), followed by Arupukottai and Coimbatore, 11.85 and 11.73 g /seedling, respectively (Table 5).

After three months in the field, the seedlings from the Western zone had superior establishment and growth than those from other zones. The Coimbatore seed source had 93% survival in the field, 10% higher than Ramanathapuram, which had the lowest survival. The plant height of seedlings from the Mettupalayam seed source was highest at 48.0 cm, which was equivalent to those from Aliyar (47.6 cm) and Erode (46.9 cm). The lowest value was obtained in Trichy seedlings, 29.7 cm. Erode seed source had the largest shoot collar diameter (0.86 cm), a 39.5% increase over those from the Arupukottai seed source (Table 6).

Azadirachta indica

Significant variations were observed in germination among the *Azadirachta indica* seed sources. The highest seed germination was obtained in the seeds from Chennai (100%; Northeastern zone), Pondicherry (98%; Northeastern zone), and Vazhapaddy (97%; Northwestern zone) seed sources (Table 7).

Six months after sowing in the nursery, the mean seedling length was 41.95 cm, with the Karur seed source (53.64 cm) of the Cauvery delta zone producing the highest seedling length. Seedlings from Sathankulam of the Southern zone recorded the largest shoot collar diameter (0.54 cm). The dry matter production of seedlings was maximum in the Bodi-I seed source (2.60g/seedling) (Table 7).

Seeds collected from the Cauvery delta zone and the Northeastern zone had the best survival and growth in the field. Chennai and fifteen other seed sources recorded 100% survival in the field. This was 25% higher than seedlings from Gobichettipalayam, which registered the lowest survival (75%). Evaluation of seedlings in the field 12 months after planting showed the greatest plant height (153.10 cm) and maximum shoot collar diameter (1.99 cm) in E. Kumaralingapuram seedlings. Seedlings developing from the Sathankulam seed source had the lowest values for plant height (68.70 cm). Krishnagiri registered the lowest shoot collar diameter (0.95 cm) (Table 8).

Discussion

Variation in germination due to seed source was reported in *Tectona grandis* (Gupta and Pattanath 1975; Manonmani and Vanangamudi 1997; Indra and Basha 1999; Masilamani et al. 1999); *Liriodendron tulipifera* (Barnett and Farmer 1978); *Cedrus deodora* (Thapliyal and Gupta 1980); *Azadirachta indica* (Ezhumah 1986; Sivasamy 1991; Kumaran 1991); *Pongamia pinnata* (Kumaran 1991; Manonmani et al. 1996); *Albizia lebbeck* (Vasudeva et al. 1999) *Casuarina* spp (Misra and Banerji 1995); *Pinus roxburghii* (Thapliyal and Dhiman, 1997); *Acacia nilotica* (Suresh 1994; Krishnan and Toky 1995; Pathak 1998), and *Dalbergia sissoo* (Gera et al. 1999). This implies that genetics (Hellum 1976; Bagchi et al. 1999; Vakshasya et al. 992) and geographics (Wright 1976; Salazar 1986) play an important role in germination of seeds. However, Sivagnanam (1995) and Sivagnanam et al. (1997) in *A. indica* and Vanangamudi *et al.* (1998) in *A. nilotica* did not find any variation in germination due to seed sources.

In this study, larger variation in seedling growth parameters was observed among seed sources in all the tree species. Similar variation in growth characteristics of loblolly pine (*Pinus taeda*) was observed among seed sources by Wells and Wakeley (1966). Similar results were also reported by Pipatwattanakul (1989) and

Sukhat Lawskul (1991) in *Acacia mangium,* Triwahyono and Mimbar (1991) in *Calliandra calothyrsus,* and Paudel *et al.* (1996) in *Pinus patula.*

Literature cited

Aldhous, J.R., 1972. Nursery practices. Forestry commission. Bulletin No. 43, London.

Bagchi, S.K., Joshi, D.N., and Rawat, D.S., 1999. Variation in seed size of *Acacia* spp. *Silvae Genetica,* vol. 39, pp. 107-110.

Barnett, P.E., and Farmer, R.E., 1978. Altitudinal variation in germination characteristics of yellow poplar in the Southern Appalachians. *Silvae Genetica,* vol. 27, no. 3-4, pp. 101-104.

Bonner, F.T., 1984. Glossary of Seed Germination Terms for Tree Seed Workers, USDA Forest Service. General Technical Report, Southern Forest Experiment Station, Starkville, Mississippi, USA, pp. 30-49.

Chauhan, V.K., and S. Verma., 1993. Progeny performance of different provenances of khair (*Acacia catechu*). *Journal of Tree Sci.,* vol. 12, no. 1, pp. 51-54.

Ezumah, B.S., 1986. Germination and storage of neem (*Azadirachta indica* A. Juss.). *Seed Scence and Technology,* vol. 14, pp. 593-600.

Gera, M., Gera, N., and Ginwal, H.S., 1999. Seed source variation in germination and early growth among ten indigenous populations of *Dalbergia sissoo* Roxb. *Indian For.,* vol. 125, no. 12, pp. 1190-1197.

Gupta, T.N., and Pattanath, P.G., 1975. Factors affecting germination behaviour of teak seeds of eighteen Indian origins. *Indian For.,* vol. 10, no. 10, pp. 584-588.

Hellum, A.K., 1976. Grading seed by weight in white spruce. *Tree Planters Notes,* vol. 27, pp. 16, 17, 23.

Heydecker, W., 1972. Vigour. In: *"Viability of Seeds",* (ed. E.H. Roberts), Chapman Hall. London pp. 209-252.

Indra, E.P., and Basha, S.C., 1999. Effect of seeds from difference sources on germination and growth in teak (*Tectona grandis* L.F.) nursery. *Ann. For.,* vol. 7, no. 1, pp. 39-44.

Krishan, B., and Toky, O.P., 1995. Provenance variation in growth characteristics of *Acacia nilotica* ssp. *indica* in Arid India. *Indian For.,* vol. 121, no. 3, pp. 179-186.

Kumaran, K., 1991. Genetic analysis of seed and juvenile seedling attributes in neem (*Azadirachta indica* A. Juss.) and pungam (*Pongamia pinnata* (Linn.) Pierre) M.Sc (For.,) Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Manonmani, V., and Vanangamudi, K., 1997. Investigations on seed source variation in teak (*Tectona grandis*). In: National symposium on Natural resources management system, St. Joseph's College, Trichy, February 26-28.

Manonmani, V., Vanangamudi, K., and Rai, R.S.V., 1996. Effect of seed size on seed germination and vigour in *Pongamia pinnata. Journal of Tropical For. Sci.,* vol. 9, no. 1, pp. 1-15.

Masilamani, P., Dharmalingam, C., and Annadurai, K., 1999. Seed source variation in seed and seedling attributes of teak (*Tectona grandis* Linn. f). In: National Symposium on Forestry Towards 21st Century, Forest college and Research Institute, Mettupalayam - 641 301, Sep. 27-28, p. 95.

Misra, C.M., and Banerji, A.C., 1995. Provenance variation in *Casuarina* species with reference to germination and growth. *Journal of Tropical For.,* vol. 11, no. 3, pp. 209-211.

Panse, V.G., and Sukhatme, P.V., 1978. Statistical Methods for Agricultural Workers. ICAR., New Delhi, 327 pp.

Pathak, N.N., 1998. Field evaluation and selection of *Acacia nilotica* provenances. *Journal of Tropical For.*, vol. 14, no. IV, pp. 197.

Paudel, K.C., Amatya, S.M., and Harrison, A., 1996. Provenance trial of *Pinus maximinoii* and comparison with *Pinus wallichiana* and *Pinus patula. LARC working paper (Nepal) ISSN 1023-3393,* No. 96/38.

Pipatwattanakul, D., 1989. Provenance variation in wood basic density of *Acacia mangium* Willd. at Lodkrating plantation chachoengsao. M.Sc (For.,) Thesis, Kasetsart University, Bangkok.

Salazar, R., 1986. Genetic variation in seeds and seedlings of ten provenances of *Gliricida sepium* (Jacq.) Stend. *For. Ecol. Manage.*, vol. 16, pp. 391-401.

Sivagnanam, K., 1995. *Growth Biology, Reproduction strategy and seed production spectrum in neem (Azadirachta indica* A. Juss). Ph.D. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore- 641 003.

Sivagnanam, K., Vanangamudi, K., and Umarani, R., 1997. Effect of provenance on seed quality on neem (*Azadirachta indica*) In: IUFRO symposium on "Innovations in Forest Tree Seed Science and Nursery Technology", November 22-25, Pt. Ravishankar Shukla University, Raipur, India. p. 162.

Sivasamy, M., 1991. Net production effect, seed production spectrum and quality polymorphism as influenced by ecology in *Azadirachta indica* A. Juss. *Derris indica* L. and *Ailanthus excelsa* Roxb. seeds. Ph.D., Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Sukhat Lawskul., 1991. Provenance trials of *Acacia mangium* willd. at lad krating plantation, Chachoengsao, M.Sc. Thesis, Bangkok graduate school, Thailand.

Suresh, K.K., 1994. Growth performance of *Acacia nilotica* under diverse ecosystems. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Thapliyal, R.C., and Dhiman, R.C., 1997. Geographic variation in seed and seedling characteristics in *Pinus roxburghii* Sarg. from Himachal Pradesh. *Ann. For.*, vol. 5, no. 2, pp. 140-145.

Thapliyal, R.C., and Gupta, B.N., 1980. Effect of seed source and stratification on the germination of deodar seeds. *Seed Science and Technology,* vol. 8, pp. 145-150.

Triwahyono, R.M.Y., and Mimbar, S.M., 1991. Effect of duration of seed water soaking in any types of planting media on seedling growth of *Calliandra calothyrsus* Meisn. *Jurnal Institute Pertanian Malang,* vol. 1, no. 2, pp. 52-54.

Vakshasya, R.K., Rajora, O.P., and Rawat, M.S., 1992. Seed and seedling traits of *Dalbergia sissoo* Roxb. : Seed source variation studies among ten sources in India. *For. Ecol. Manage.*, vol. 48, pp. 265-275.

Vanangamudi, K., Umarani, R. Bharathi, A., and Venkatesh, A., 1998. Effect of seed source on physical and physiological qualities of *Acacia nilotica* seeds. *Seed Research,* vol. 26, no. 2, pp. 114-116.

Vasudeva, R., Shashidhara, G.B., and Haseeb, M.A., 1999. Identification of plus trees of *Albizia lebbeck* (L. Benth.) in Karnataka. In: National Symposium on Forestry Towards 21st Century, Forest college and Research Institute, Mettupalayam - 641 301, Sep. 27-28. p. 25.

Wells, O.O., and Wakeley, P.C., 1966. Geographic variation in survival, growth and fusiform- Must infection of planted loblolly pine. *For. Sci. Monogr.* 11.

Wright, J.W., 1976. Introduction to forest genetics, Academic Press, New York, 463 pp.

Table 1. Seed sources and their locations.

Acacia nilotica	*Albizia lebbeck*	*Azadirachta indica*
North eastern zone	**North eastern zone**	**North eastern zone**
Vellore	Chenglepet	Chennai
Tirupattur		Chittoor
Tiruvanamalai		Thiruvallur
North western zone	**North western zone**	Gudiyatham
Salem	Salem	Paratharami
Dharmapuri		Villupuram
		Cuddalore
Western zone	**Western zone**	Pondicherry
Erode	Anamalai WLS	Chengam
Coimbatore	Aliyar	Thiruvannamalai
Aliyar	Coimbatore	**North Western Zone**
	Mettupalayam	Krishnagiri
	Erode	Dharmapuri
Southern zone	**Southern zone**	Malaipaiyur
Virudhunagar	Tirunelveli	Vazhapaddy
Kovilpatty	Ramanathapuram	Namakkal
Madurai	Madurai	**Western zone**
Paramakudi	Arupukottai	Andipatty (Udumalpet)
Cumbum		Sathyamangalam
Periyakulam		Gobichettipalayam
	Cauvery Delta Zone	Erode
	Trichy	Anthiyur (Pudupalayam)
		Kurumandur
		Kangayam
		Palladam
		Mettupalayam
		Seeranaicken Palayam
		Southern zone
		Madurai
		Karaikudi (Pallattur)
		Bodi-I (Sankarapuram)
		Bodi-II (Keelachindalai)
		Sattur
		E.Kumaralinga Puram
		Irrukangudi
		Uthupatty (Kovilpatti)
		Paramakudi
		Ramanathapuram
		Aruppukottai
		Sathankulam
		Tirunelveli
		Shengottai
		Cauvery delta zone
		Aduthurai
		Tiruvarur
		Velankanni
		Trichy (Navalur)
		Trichy (Kumulur)
		Karur
		High rainfall zone
		Kanyakumari

Table 2. Physiographic and climatic details of the agroecological zones in Tamil Nadu.

Zone	Geographical extent		Soil type	Mean temperature (°C)	Annual rain fall (mm)
	Latitude	Longitude			
North eastern zone	8° 5' – 13° 2' N	76° 15' – 80° 22' E	Red loam, clay loam, coastal alluvial	21 – 28 28 – 37	1100
North western zone	11 – 12° 55' N	77° 28' – 78° 50' E	Red loam, black soil	20 – 26 30 – 37	849
Western zone	9° 30' – 12° N	70° 30' – 78° E	Red soil, black soil	20 – 26 30 – 37	776
Cauvery delta zone	11° 48' N	78° – 79° 36' E	River-alluvial coastal, alluvial, black soil, red sandy loam	21 – 27 30 – 38.5	900
Southern zone	8° – 10° 55' N	77° – 79° 50' E	River-coastal, alluvial, black soil, red sandy loam	21 – 27.5 30 – 38	720
High rainfall zone	8° 03' – 8° 35' N	77° 5' – 77° 36' E	Sandy alluvial red loam, laterite	22 – 26 29.5 – 35	1465

Table 3. Performance of *A. nilotica* seed sources under nursery condition 6 months after sowing.

Seed source (S)	Germination (%)	Shoot length (cm)	Root length (cm)	Shoot collar diameter (mm)	Dry matter production (g/seedling)
Vellore	92 (73)	82.5	31.0	5.8	8.027
Tirupattur	95 (77)	83.0	32.4	5.2	9.402
Tiruvanamalai	70 (58)	57.8	23.0	5.0	4.852
Salem	75 (60)	81.3	21.5	5.2	6.774
Dharmapuri	74 (59)	69.5	23.0	5.2	5.067
Erode	81 (64)	68.1	22.5	5.1	5.146
Coimbatore	84 (66)	75.5	26.5	5.4	5.257
Aliyar	85 (67)	69.0	22.3	4.8	7.834
Virudhunagar	79 (63)	69.0	23.5	5.3	6.218
Kovilpatty	76 (61)	72.0	20.8	4.8	5.157
Madurai	90 (73)	70.0	29.0	4.9	5.485
Paramakudi	83 (66)	65.5	23.5	4.9	5.614
Cumbum	91 (73)	64.0	29.5	5.0	6.146
Periyakulam	82 (65)	70.5	26.0	4.5	6.043
Mean	83 (66)	71.3	26.0	5.1	6.215
SEd	2.18	2.38	2.10	-	0.497
CD (P=0.05)	4.37	5.10	4.51	NS	1.065

Table 4. Performance of different seed sources of *A. nilotica* seedlings in the field 16 months after planting.

Seed source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)
Vellore	89 (71)	319.0	5.2
Tirupattur	91 (73)	327.5	6.0
Tiruvanamalai	75 (60)	208.5	2.3
Salem	87 (69)	151.0	2.2
Dharmapuri	91 (73)	197.0	3.1
Erode	79 (63)	238.0	4.5
Coimbatore	79 (63)	286.0	4.1
Aliyar	91 (73)	239.0	4.6
Virudhunagar	74 (60)	279.5	3.9
Kovipatty	89 (71)	188.5	2.8
Madurai	77 (61)	308.5	4.6
Paramakudi	89 (71)	240.5	4.2
Cumbum	85 (67)	324.0	5.1
Periyakulam	57 (69)	284.0	3.6
Mean	85 (67)	256.5	4.0
SEd	1.20	4.59	0.08
CD (P=0.05)	2.60	9.85	0.17

(Figures in parentheses indicate arc sine transformed values)

Table 5. Assessment of seedling growth and biomass of *Albizia lebbeck* from different seed sources under nursery conditions at six months after sowing.

Seed sources	Germination (%) at 28 days after sowing	Root length (cm)	Shoot length (cm)	Shoot collar diameter (cm)	Total dry weight (g seedling^{-1})
Tirunelveli	94 (76)	46.47	23.07	0.9	13.02
Ramanathapuram	87(68)	37.60	20.80	0.7	8.33
Madurai	82 (64)	47.63	28.17	0.6	10.48
Arupukottai	80 (63)	45.67	31.57	0.8	11.85
Anamalai WLS	91 (72)	39.43	24.97	0.7	10.46
Aliyar	76 (60)	43.67	27.70	0.9	10.65
Coimbatore	79 (62)	49.47	30.67	0.7	11.73
Mettupalayam	90 (71)	38.33	24.67	0.8	9.06
Erode	87 (69)	35.80	26.50	0.6	8.38
Salem	68 (55)	32.33	31.37	0.5	8.09
Chinglepet	64 (53)	30.60	21.30	0.9	7.88
Trichy	60 (50)	28.77	22.77	0.8	7.39
Mean	80 (64)	39.65	26.13	0.8	9.78
SEd	1.67	0.430	0.371	0.05	0.071
CD (P=0.05)	3.45	0.886	0.766	0.10	0.146

(Figures in parentheses indicate arc sine transformed values)

Table 6. Field performance of different seed sources of *A. lebbeck* seedlings three months after planting.

Seed source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)
Tirunelveli	89 (70)	45.2	0.63
Ramanathapuram	83 (65)	39.6	0.57
Madurai	86 (68)	44.2	0.57
Arupukottai	84 (66)	44.6	0.52
Anamalai WLS	86 (68)	35.6	0.71
Aliyar	88 (69)	47.6	0.56
Coimbatore	93 (75)	37.5	0.57
Mettupalayam	86 (68)	48.0	0.53
Erode	90 (71)	46.9	0.86
Salem	86 (68)	29.5	0.56
Chinglepet	87 (69)	31.3	0.60
Trichy	85 (66)	29.7	0.54
Mean	87 (69)	40.0	0.60
SEd	1.2	0.91	0.012
CD (P=0.05)	2.4	1.87	0.025

(Figures in parentheses indicate arc sine transformed values)

Table 7. Assessment of seedling growth and biomass of *Azadirachta indica* from different seed sources under nursery conditions six months after sowing.

Seed Source	Germination (%)	Seedling length (cm)	Shoot collar diameter (cm)	Dry matter production (g seedling^{-1})
Chennai	100 (90)	46.12	0.44	1.802
Chittoor	80 (63)	41.35	0.39	1.542
Thiruvallur	79 (62)	38.04	0.42	1.738
Gudiyatham	83 (65)	45.74	0.40	1.905
Paratharami	88 (69)	44.60	0.44	1.911
Villupuram	67 (54)	41.32	0.40	2.002
Cuddalore	68 (55)	42.61	0.42	1.809
Pondicherry	98 (81)	44.45	0.41	2.341
Chengam	93 (75)	41.40	0.42	2.502
Tiruvanamalai	12 (20)	35.75	0.43	1.665
Krishnagiri	65 (53)	44.15	0.48	1.504
Dharmapuri	82 (64)	42.75	0.39	1.490
Malaipaiyur	95 (80)	44.15	0.47	1.934
Vazhapaddy	97 (80)	39.75	0.41	1.468
Namakkal	72 (58)	42.95	0.46	2.304
Aduthurai	84 (66)	42.40	0.41	1.637
Tiruvarur	89 (70)	39.15	0.42	1.734
Velankanni	70 (56)	42.35	0.52	1.356
Trichy (Navalur)	71 (57)	42.50	0.41	1.530
Trichy (Kumulur)	88 (69)	44.55	0.38	1.742
Karur	85 (67)	53.64	0.49	2.135
Andipatty	73 (58)	36.12	0.43	1.292
Sathyamangalam	88 (69)	41.56	0.46	1.805
Gobichettipalayam	75 (60)	42.04	0.43	1.641
Erode	83 (65)	47.18	0.44	2.279
Anthiyur	76 (60)	40.56	0.43	2.035
Kurumandur	85 (67)	43.45	0.42	1.884
Kangayam	79 (62)	44.72	0.40	1.716
Palladam	90 (71)	42.63	0.41	1.905
Mettupalayam	86 (68)	39.17	0.40	1.832

Seed Source	Germination (%)	Seedling length (cm)	Shoot collar diameter (cm)	Dry matter production (g seedling^{-1})
Seeranaickenpalayam	88 (69)	42.26	0.45	1.646
Madurai	81 (64)	42.82	0.43	1.719
Pallattur	60 (50)	41.37	0.44	1.602
Bodi-I	86 (68)	46.75	0.52	2.603
Bodi-II	82 (64)	41.42	0.51	2.811
Sattur	80 (63)	41.62	0.49	1.882
E.Kumaralingapuram	78 (62)	39.85	0.42	1.801
Irrukangudi	60 (50)	37.94	0.40	1.405
Uthupatty	68 (55)	40.45	0.51	2.506
Paramakudi	55 (47)	38.44	0.39	1.905
Ramanathapuram	62 (51)	41.53	0.41	1.611
Aruppukottai	90 (71)	40.63	0.42	1.735
Sathankulam	65 (53)	44.17	0.54	1.942
Tirunelveli	56 (48)	39.36	0.48	2.401
Shengottai	58 (49)	40.45	0.41	1.407
Kanyakumari	71 (57)	43.68	0.49	1.801
Mean	77.00	41.95	0.438	1.853
SEd	3.627	0.5461	0.0406	0.0038
CD (P=0.05)	7.299	1.0799	0.0804	0.0076

(Values in parentheses indicate arc sine transformation)

Table 8. Field performance of different seed sources of *Azadirachta indica* seedlings 12 months after planting.

Seed Source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)
Chennai	100	114.50	1.47
Chittoor	83	75.30	1.10
Thiruvallur	100	120.00	1.67
Gudiyatham	100	148.00	1.93
Paratharami	85	86.00	1.38
Villupuram	100	93.50	1.40
Cuddalore	100	83.75	1.18
Pondicherry	100	132.00	1.67
Chengam	100	130.70	1.86
Krishnagiri	80	87.70	0.95
Dharmapuri	88	132.00	1.54
Malai paiyur	83	108.50	1.25
Vazhapaddy	95	114.45	1.38
Namakkal	80	78.00	1.30
Aduthurai	100	136.20	1.76
Tiruvarur	97	121.80	1.52
Velankanni	100	124.00	1.85
Navalur(trichy)	100	112.70	1.27
Kumulur(trichy)	100	101.40	1.45
Karur	85	93.50	1.57
Andipatty	80	99.00	1.55
Sathyamangalam	98	118.50	1.60
Gobichettipalayam	75	109.00	1.24
Erode	80	71.30	1.40
Anthiyur	80	108.00	1.42
Kurumandur	98	104.20	1.31
Kangayam	98	136.00	1.63
Palladam	100	138.40	1.66
Mettupalayam	100	132.60	1.89

Seed Source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)
Seeranaickenpalayam	95	133.10	1.73
Madurai	100	115.50	1.42
Pallattur	80	103.00	1.50
Bodi-i	84	97.80	1.43
Bodi-ii	98	146.30	1.86
Sattur	98	145.00	1.99
E.Kumaralingapuram	100	153.10	1.99
Uthupatty	80	127.50	1.80
Aruppukottai	90	89.55	1.45
Sathankulam	90	68.70	1.10
Shengottai	80	82.70	1.20
Paramakudi	100	128.80	1.60
Irukkangudi	88	74.70	1.20
Ramanathapuram	100	82.00	1.40
Kanyakumari	100	105.50	1.37
Mean	92.45	110.55	1.506
SEd	3.422	2.469	0.108
CD (P=0.05)	6.878	4.884	0.214

Tetrazolium Viability Testing – A Reliable Quick Viability Test for Some Tropical Tree Species

K. Vanangamudi[1], G. Mani, R. Umarani, A. Venkatesh and S. Natarajan
Department of Seed Science and Technology
Tamil Nadu Agricultural University
Coimbatore – 641 003, Tamil Nadu, India

Abstract

The International Seed Testing Association (1993) has standardized and prescribed rules for some tree species, mostly temperate. However, information is lacking for seed testing standards and procedures for tropical tree species. The aim of seed testing in forestry is to assess the planting value of a seed lot. This helps to determine the quantity of seeds required per unit area of the nursery bed. Tetrazolium staining is a dependable and an acceptable biochemical method for rapid viability testing.

Quick viability testing is very important in forest seeds which requires longer time to germinate or may exhibit varying types of dormancy, or for seeds which lose their viability very quickly. In view of this, investigations were carried out for seeds of *Albizia lebbeck, Acacia nilotica, Azadirachta indica,* and *Casuarina equisetifolia, Albizia lebbeck.* Seeds were collected from 12 different seed sources of Tamil Nadu and tested with 0.50 % and 1 % tetrazolium concentration. The study revealed that nipping off the seed coat followed by 12 h water soaking and longitudinal splitting of cotyledons was the best suited preconditioning method. The use of 1 % 2, 3, 5 TZ chloride proved optimum for testing the viability of the seeds. The TZ test conducted for fourteen seed sources of *Acacia nilotica* revealed that acid scarification for 60 min. followed by 12 h water soaking and longitudinal splitting of cotyledons was the best preconditioning method. The optimum concentration of the TZ solution is 0.75 %. In the case of neem seeds collected from 17 different seed sources of Tamil Nadu were used for the study. The results indicated that decoating the seeds followed by 12 h of water soaking and longitudinal splitting of cotyledons was the best preconditioning method with 0.2 % TZ chloride as the optimum concentration. *Casuarina equisetifolia* seeds collected from five candidate plus trees were utilized for TZ test standardization. The study revealed that 0.75 % tetrazolium chloride solution was optimum to identify the viable and nonviable seeds. In all the tree species, a high positive correlation was obtained between the viability percentage estimated by the tetrazolium test and the standard germination test.

Keywords: Tetrazolium test, rapid seed viability test

Introduction

Large quantities of seeds are needed for tree planting programmes. The seeds have to be tested and certified for optimum germination and vigour. The International Seed Testing Association (1993) has standardized and prescribed rules for some tree species, mostly temperate species. However, it lacks information for the seed testing standards and procedures for tropical tree species. Seed certification in forestry is different from that of the certification in agriculture where generation systems are followed. In forestry, a certificate may be issued for seeds from Seed Production Areas (SPA) and plus trees. The aim of seed testing in forestry is to assess the planting value of a seed lot. This helps to determine the quantity of seeds required per unit area of the nursery bed. Hence, standardization is important for the weight of submitted and working sample size, purity analysis, seed weight, germination medium, and the tetrazolium test. The tetrazolium test is useful for rapid testing of seed viability (Lakon 1949). The tetrazolium test is a dependable and an acceptable biochemical method for rapid viability testing. This is especially important in forest seeds that require a much longer time to germinate or may exhibit various types of dormancy.

[1] Author for correspondence

From the inception of use of tetrazolium chloride for viability testing by Lakon (1942), numerous workers have successfully used it for the rapid determination of seed viability (Gopal and Thapliyal 1969; Mackay 1972; Moore 1973; Gupta and Raturi 1975). Standard procedures for particular species have been developed in various parts of the world (Agarwal et al. 1973; Gopal and Thapliyal 1969; Gupta and Raturi 1975; Singh 1986; Sivasubramanian and Prabakaran 1991; Prasad and Kandya 1992; Purohit et al. 1996; Jerlin 1998; Bharathi 1999; Natarajan 1999; Umarani 1999). When an ISTA certificate has not been issued, the analyst is free to choose a concentration suited for the purpose. In fact, the concentration of the solution is not fixed thus concentrations of 0.1% to 1.0% may be used successfully (Overaa 1979).

Materials and Methods

Acacia nilotica

The seeds of karuvel (*Acacia nilotica* ssp. *indica*) were collected from the identified superior trees from fourteen seed sources (Table 1) in four agroclimatic zones of Tamil Nadu. From each seed source, four replications of 100 seeds each, drawn at random from the pure seed fraction, were used for this study. The design employed for this study was completely randomized design.

The seeds were acid scarified (60 min.) followed by 12 h water soaking. The seed coat was completely removed without injury to the embryo. The cotyledons were cut transversely.

The cotyledons were soaked in 0.25, 0.50, 0.75, and 1.0% aqueous solution of 2, 3, 5-triphenyl tetrazolium chloride with pH range of 6.5-7.5 and kept in a hot air oven maintained at 35 ± 2°C for 2 h for staining. The viable and non-viable seeds were resolved as per ISTA (1993) rules.

Albizia lebbeck

The seeds gathered from 12 seed sources from different agroclimatic zones of Tamil Nadu were used for this study (Table 2). Four replicates of 100 seeds each drawn at random from the pure seed fraction were used for the tetrazolium test. The design used for this study was completely randomized design with four replications.

Preconditioning methods

The preconditioning methods include (1) acid scarification followed by 12 h water soaking, and (2) nipping off the seed coat followed by 12 h water soaking.

Preparation methods

Preparation methods include: (1) complete removal of seed coat without injury to the embryo, (2) removal of seed coat and splitting of the cotyledons with careful retention of the embryo in one of the cotyledons, and (3) removal of seed coat and cutting the cotyledons transversely.

Tetrazolium concentration

The seeds, after preconditioning and preparation, were soaked in 0.5 and 1.0% aqueous solution of 2, 3, 5-triphenyl tetrazolium chloride with pH range of 6.5-7.5 and kept in a hot air oven maintained at 40 ± 2°C for 2 h. The viable and non-viable seeds were grouped as per ISTA (1993) rules.

Azadirachta indica

From seventeen seed sources (Table 3), four replications of 100 seeds, each drawn at random from the pure seed fraction, were used for this study. The design employed for this study was completely randomized design.

The seeds were soaked in water for 12 h. The seed coat (Kernel) was completely removed without injury to the embryo. The cotyledons were cut transversely.

The cotyledons were soaked in 0.1 and 0.2% aqueous solution of 2, 3, 5-triphenyl tetrazolium chloride with pH range of 6.5-7.5 and kept in a hot air oven maintained at 35 ± 2°C for 2 h for staining. The viable and non-viable seeds were categorized as per ISTA (1993) rules.

Casuarina equisetifolia

The true seeds present inside the capsules were pricked out with a dissecting needle. The seeds were soaked in different concentrations of 2-3-5 triphenyl tetrazolium chloride solution viz., 0.25, 0.50, 0.75, and 1.00 % and incubated in darkness for 24 hr.

Results

Acacia nilotica

The present study was carried out with fourteen seed lots of *Acacia nilotica.* Acid scarification for 60 min. followed by 12 h water soaking and longitudinal splitting of cotyledons were the best preconditioning and preparation methods, respectively, for the tetrazolium test. Viability estimates differed significantly among the four concentrations used in the study (0.25, 0.50, 0.75, and 1.00 %). Based on the staining pattern, it was decided that 0.75 % concentration is optimum to perform the topographical tetrazolium test in *A. nilotica* (Table 1).

Albizia lebbeck

The present investigation was carried out for twelve seed lots. Nipping off the seed coat followed by 12 h water soaking were the best preconditioning method for this species. The best preparation method is longitudinal splitting of cotyledons. Viability estimates by f the two concentrations, 0.5% and 1.0% of the 2-3-5 triphenyl tetrazolium chloride differed significantly. The seeds recorded 82.3 and 83.2% viability at 0.5 and 1.0%, respectively. The results indicated that 1.0% was the better concentration to estimate the viability percentage of the seeds (Table 2).

Azadirachta indica

Of the tetrazolium concentrations used, 0.1% and 0.2%, the 0.2% concentration proved promising. The other concentration had indistinct staining, and it was difficult to distinguish the viable and non-viable seeds. In 0.2 % concentration, the viable seed percent was 48%. Among the zones, the Northwestern zone had the highest viable seed percentage (62%) and the Cauvery delta zone had the least (37%). Bhavanisagar of the Western zone had the highest viable seed percentage (85%) at 0.2% concentration. The mean viable seed percentage with 0.1% tetrazolium concentration is 39% (Table 3).

The non-viable seed estimate was more (61%) in 0.1% and less (52%) in 0.2% tetrazolium concentration. Among the zones, nonviable seed estimate was most (63%) in the Cauvery delta zone and least (38%) in the Northwestern zone at 0.2% concentration. The interaction effect revealed that the Kumulur seed lot of the Cauvery delta zone had the maximum non-viable seed estimate (97%) at 0.1% tetrazolium concentration (Table 3).

Casuarina equisetifolia

The experiment conducted with the true seeds of *C. equisetifolia* obtained after removing the seed coat is in accordance with the 'method 9' of preparation for tetrazolium absorption listed by Moore (1973). The true seeds were soaked in 0.25, 0.50, 0.75, and 1.0% of 2, 3, 5 triphenyl tetrazolium chloride solutions for 24 h (Overaa 1979). The 0.25 % resulted in very faint staining, and 1.00% resulted is very dark staining. The best concentrations are 0.50% and 0.75%. Seeds of *C. equisetifolia* should be removed from the capsule and should be soaked in 0.75 % tetrazolium solution in order to obtain the best staining.. This will help in differentiating the viable parts from nonviable and mechanically damaged parts of the seeds.

The results revealed that there was a steady decline in viability from 92.5 %, recorded in fresh seeds, to 90.5% after one month of storage and 83.4, 53.0, 51.7, and 30.1% after three, five, seven, and nine months of storage, respectively. As the ageing period progressed, the completely stained seeds decreased

progressively from 85.7% in the fresh seeds to 7.50% after nine months of storage. Alternatively, the seeds that stained discontinuously (i.e. unstained patches were prevalent amidst the actively stained seeds) increased progressively from 2.8% (fresh seeds) to 22.6% (nine month old seeds) (Table 4).

Discussion

In the topographical tetrazolium test, a colourless solution of 2, 3, 5 - triphenyl tetrazolium chloride or bromide is used as an indicator to reveal the reduction processes which take place within living cells. The chemical is imbibed by the seed. Within the seed tissues, this chemical reacts with the reduction processes of living cells and accepts hydrogen from the dehydrogenase enzymes. By hydrogenation of the 2, 3, 5 - triphenyl tetrazolium chloride, a red, stable, and non-diffusable substance, triphenyl formazan, is produced in living cells. This makes it possible to distinguish the red-coloured living parts of seeds from the colourless dead ones (ISTA 1993).

The phenomenon of declining viability of seeds in storage may explain the reduction not only of viability but also vigour of seeds as the chronological age increases. Staining with tetrazolium is due to the dehydrogenase enzyme, which is involved in the respiration process of living tissues (Moore 1973). Lack of active staining is the proof for decreased respiratory activity which is a measure of seed vigour (Heydecker 1972).

Raspet (1965) proposed that in seed storage studies, the deterioration of the seed can be followed by the difference in the staining patterns obtained. This could be due to physiological changes taking place in a seed as a result of ageing or injury.

References

Agarwal, P.K., Karihaloo, J.L., Ahmed, S.M.M., and Gupta, P.C., 1973. Predicting germinability in maize, wheat and paddy seed on the basis of tetrazolium test. *Seed Research,* vol. 1, pp. 83-85.

Bharathi, A., 1999. Studies on handling, management and storage of neem seed (*Azadirachta indica* A. Juss). Ph.D. Thesis in Seed Science and Technology. Tamil Nadu Agricultural University, Coimbatore - 641 003.

Gopal, M., and Thapliyal, R.C., 1969. Topographical tetrazolium test of Indian tree seeds. *Van Vig,* pp. 37-45.

Gupta, B.N., and Raturi, A.S., 1975. Tetrazolium staining of seeds for interpretation of viability of six Indian tree species. *Indian For.,* vol. 101, no. 11, pp. 659-673.

Heydecker, W., 1972. Vigour. In: *"Viability of Seeds",* (ed. E.H. Roberts). Chapman Hall, London, pp. 209-252.

ISTA, 1993. International rules for seed testing. *Seed Science and Technology,* vol. 21, pp. 1-288.

Jerlin, R., 1998. Seed technological studies on Pungam (*Pongamia pinnata* L. Pierre). Ph.D. Thesis in Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Lakon, G., 1942. Topographischer Nachwies der akeimfahigkeit der Gettreidefruchte durch Tetrazolium-Salze. *Ber Deutsch. Bot. Ges.,* vol. 60, pp. 299-305.

Lakon, G., 1949. The topographical tetrazolium method for determining the germinative capacity of seeds. *Plant Physiology,* vol. 24, pp. 389-394.

Mackay, D.B., 1972. The measurement of viability of seeds, (ed. E.H. Roberts) Chapman Hall, London, pp. 172-208.

Moore, R.P., 1973. Tetrazolium staining for assessing seed quality. In: Seed Ecology (ed. W. Heydecker), pp. 347-366.

Natarajan, S., 1999. Investigations on seed source variations, standardization of seed testing procedures and nursery techniques in *Albizia lebbeck* (L.) Benth. Ph.D., thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Overaa, P., 1979. Introduction to biochemical test for viability programme. *Seed Science and Technology,* vol. 7, pp. 591-596.

Prasad, R., and Kandya, A.K., 1992. Handling of forestry seeds in India. Associated Publishing Company, New Delhi, 237 pp.

Purohit, M., Mishra, G.P., and Jamaluddin, 1996. Tetrazolium staining of seeds for testing of viability of some tropical tree species. *Journal Trop. For.,* vol. 12, no. 111, pp. 166-170.

Raspet, M.W., 1965. The tetrazolium test proceedings seedmens short course, Missisipi State University, State College, Missisipi.

Singh, N.B., 1986. Tetrazolium test for viability of seeds of two Indian tree species. In: Proc. of the National Seminar on Forest Tree Seed, Indo-Danish Project on Seed Procurement and Tree Improvement Andhra Pradesh Forest Department, Hyderabad, January.

Sivasubramanian, K., and Prabakaran, J., 1991. Topographical tetrazolium test for sekakai (*Acacia concinna*). *Van. Vig,* vol. 29, no. 1, pp. 5-8.

Umarani, R., 1999. Studies on the physiological and biochemical basis of seed germination and deterioration in *Casuarina equisetifolia.* Ph.D. Thesis in Seed Science and Technology. Tamil Nadu Agricultural University, Coimbatore-641 003.

Table 1. Rapid viability test in *A. nilotica* using 0.75% 2, 3, 5-triphenyl tetrazolium chloride.

Seed source (S)	Viable seeds (%)	Nonviable seeds (%)*
Vellore	86.3	13.5
Tirupattur	92.5	7.5
Tiruvanamalai	85.0	15.0
Salem	84.8	15.2
Dharmapuri	85.7	14.3
Erode	69.9	30.1
Coimbatore	84.8	15.2
Aliyar	86.2	13.8
Virudhunagar	74.5	25.5
Kovilpatty	83.8	16.2
Madurai	86.4	13.6
Paramakudi	87.6	12.4
Cumbum	85.1	14.9
Periyakulam	83.2	16.8
Mean	84.0	16.0

(Note: *Not analysed statistically)

Table 2. Rapid viability test (Tetrazolium test) of *A. lebbek.*

Seed lot (L)	Viable seed (%)			Non-viable seed (%)		
	Tetrazolium concentration (C)			Tetrazolium concentration (C)		
	0.5 %	1.0%	Mean	0.5%	1.0 %	Mean
Tirunelveli	88.3	84.0	86.0	11.7	16.0	13.8
Ramanathapuram	82.0	76.7	79.3	18.0	23.3	20.7
Madurai	84.3	80.7	82.5	15.7	19.3	17.5
Arupukottai	79.0	83.3	87.2	21.0	16.7	18.8
Anamalai WLS	88.0	91.7	89.8	12.0	8.3	10.2
Aliyar	79.3	83.7	81.5	20.7	16.3	18.5
Coimbatore	83.0	87.7	85.3	17.0	12.3	14.7
Mettupalayam	90.0	94.7	92.3	10.0	5.3	7.7
Erode	83.7	79.3	81.5	16.3	20.7	18.5
Salem	74.0	82.0	78.0	26.0	18.0	22.0
Chinglepet	78.3	74.7	76.5	21.7	25.0	23.3
Trichy	77.3	80.3	78.8	22.7	19.7	21.2
Mean	82.3	83.2		17.7	16.8	
	L	C	L x C	L	C	L x C
SEd	0.78	0.32	1.10	0.78	0.32	1.10
CD (P=0.05)	1.57	0.64	2.22	1.58	0.64	2.20

Table 3. Rapid viability test (Tetrazolium test) of *Azadirachta indica.*

Seed lot (L)	Viable seed (%)			Non Viable seed (%)		
	Tetrazolium concentration (C)			Tetrazolium concentration (C)		
	0.1 %	0.2 %	Mean	0.1 %	0.2 %	Mean
North Eastern Zone						
Vellore	53.1	66.5	59.80	46.9	33.5	40.20
Cuddalore	15.4	29.1	22.25	84.6	70.9	77.75
Chengam	17.0	25.6	21.30	83.0	74.4	78.70
Mean	28.5	40.4		71.5	59.6	
North Western Zone						
Pennagaram	68.2	77.4	72.80	31.8	22.6	27.20
Krishnagiri	51.7	70.5	61.10	48.3	29.5	38.90
Vazhapaddy	29.6	37.1	33.35	70.4	62.9	66.65
Mean	49.8	61.6		50.2	38.3	
Cauvery delta zone						
Navalur (Trichy)	77.0	82.5	79.76	23.0	17.5	20.25
Velankanni	20.1	23.3	21.70	80.1	76.7	78.30
Kumulur (Trichy)	3.5	5.2	4.35	96.5	94.8	95.65
Mean	33.5	37.0		66.5	63.0	
Western Zone						
Bhavanisagar	80.2	84.7	82.45	19.8	15.3	17.55
Aliyarnagar	62.4	66.6	64.50	37.6	33.4	35.50
Erode	13.1	24.5	18.82	86.8	75.5	81.17
Mean	51.9	58.6		48.1	41.4	
Southern Zone						
Uthupatty	69.5	75.4	72.45	30.5	24.6	27.55
Ramanathapuram	24.9	35.1	30.00	75.1	64.9	70.00
Periyakulam	3.0	7.2	5.10	97.0	92.8	94.90
Mean	32.5	39.2		67.5	60.8	
High Rainfall Zone						
Kanyakumari	47.2	69.0	58.10	52.8	31.0	41.90
Nagercoil	23.4	30.1	26.75	76.6	69.9	73.25
Mean	35.3	50.0		64.7	51.0	
Grand Mean	38.79	47.64		61.21	52.36	
	L	C	L x C	L	C	L x C
SEd	0.1433	0.0491	0.2026	0.1711	0.0587	0.2420
CD (P=0.05)	0.2842	0.0975	0.4019	0.3394	0.1164	0.4800

Table 4. Staining pattern and viability percentage observed after the quick viability test (TZ test) in *C. equisetifolia.*

Months of storage	Viable seeds (%)		Non-viable seeds (%)				Viable seeds (%)	Dead seeds (%)
	Completely stained	Discontinuously stained	Radical tip unstained	Pale brown imbibed unstained	Brown-darkened radical unimbibed unstained	Black unstained		
0	85.7	6.80	3.7	-	3.8	-	92.5	7.5
1	83.7	8.20	4.1	-	4.0	-	90.5	9.5
3	58.0	25.40	-	8.3	26.3	-	83.4	16.6
5	32.6	20.40	-	8.9	27.4	1.0	53.0	47.0
7	8.7	43.00	-	-	37.5	3.5	51.7	48.3
9	7.5	22.60	-	7.5	62.2	-	30.1	69.9

(Note: Not analysed statistically)

Current Production and Future Requirement of Wood and Wood Products in India

S.Varadharaj[1], L.P.Swaminathan[1], A. Vidhyavathi[1] and C.Sekhar[2]

[1]Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.

[2]Forest College and Research Institute, Mettupalayam, Tamil Nadu, India.

Abstract

In India, forest cover occupy nearly 63.33 million ha (19.3 per cent), of this area 54.5%, 29.1%, and 16.1% are under reserve, protected, and unclassified forests. The reserve forest is permanently devoted to the production of timber. Wood plays an important role in all sectors and wood utilization over the years. This paper analyzed the trend in production and demand-supply imbalances of wood and wood products in India. The wood was classified into round wood and industrial wood, and the wood products were classified into plywood, particleboard, and fiberboard. The compound growth rates had revealed that there was a consistent increase for round wood and industrial wood (2.02%, and 2.02%). The production of round wood and industrial wood increased from 167.8 million cubic meters and 12.69 million cubic meters in 1970 to 299.4 million cubic meters, and 25.156 million cubic meters in 1998. This implied that despite the ban on forest felling, the production of wood increased in India. By 2010, demands for round wood and industrial wood were estimated to be 382.72 million m^3 and 38.42 million m^3respectively. However, supply was determined to be 380.72 million m^3 for and 31.97 million m^3 for industrial wood. The compound growth rates for ply wood, particle board, and fiberboard were 3.04%, 7.25%, and 2.02% respectively, but the annual growth rate for plywood for the years 1972, 1973, 1975, and 1992 remained low when compared with the base year (1970). Though production of wood products showed increasing trend, the projected demand for plywood, particleboard, and fiberboard (0.38, 0.16, and 0.10 million cubic meters respectively) were more than the supply (0.35, 0.14, and 0.04 million cubic meters). This indicates serious shortage of wood and wood products in future. This could be met by growing more valuable tree species on forest and non-forestlands such as degraded lands and agricultural wastelands etc. The wood of non-durable species, wood waste, other lofted twigs of durable species, and agricultural wastes could also be used with modern wood preservation techniques to meet the future requirement of wood and wood products in India.

Keywords: Round wood, industrial wood, plywood, particleboard, fiberboard, demand, supply, and imbalance.

Introduction

Indian rural economy depends upon forestry. With its land area at 328.8million ha, India's population verges on 700 million of this. Eighty percent of the land area is rural dispersed over 6.7 lakh villages. Forest cover occupy nearly 63.33 million ha (19.3%). The desirable percentage is 1/3 of the total land surface (76.5M.ha). Of the forested area, 54.5% is under reserve forest, 29.1% is under protected forest, and 16.4% belongs to the unclassified forest. Out of which 95 per cent is under the ownership of state. Reserved forest is permanently devoted to the production of timber or other forest products. 59.7 per cent of the forest area is at present exploited and used to cater to the public demands for forest products. Forest plays a major role in the country's economic development and ecological stability. They provide several goods broadly classified as major and minor forest products, which serve as raw materials for many industries and contribute to the country's export earning. The contribution of forest to India's GNP is about 2%.

Of the major forest products, wood and wood products play important roles in the industrial sector. Wood is a versatile product. Wood utilization over the centuries has diversified into many products like plywood, fiberboard, and particleboard. With the passage of time and advancement of technology, there has been a tremendous variety with the use of wood products. The advancement of human civilization coupled with that of the power-based industries have further enhanced the need for industrial wood.

The household, industry, and tertiary sectors use round and industrial wood. In the household sector, timber is used for house construction and furniture making. In the industry sector, wood is used as raw material for the manufacture of match furniture, pencil, photo-frames, boat making, handicrafts, pulp and paper etc. In the tertiary sector, wood is used for business establishments, restaurants, hotels, hospital railways, road construction etc.

The Indian plywood industry owes its development to the growth of the tea industry particularly the fabrication of wooden chests for packaging tea for export. In 1978, there were 186 plywood-manufacturing units in the country including 40 large-scale units. Now there are more than 500 plywood manufacturing units. There are 80 species suitable for plywood. The important species are *Mangiferà indica, Ckukrasia tabularies, Schima assamica, Tectona grandis, Toona ciliata, and Dalbergia latifolia.*

The first particleboard plant was built in Germany in 1941. The progress of particleboard industry in India has been rapid. Particleboard industry in this country is generally integrated with other industries. Particleboard is a complementary good to high quality plastics laminates. The suitable species for particleboard are *Holoptelia integrifolia, Mangifera indica, and Adina cardifolia, etc.*

The raw material for the industries consist of inferior woods, wood residues, lops and tops, wood trimmings, core of peeled logs, and veneer wastes. The suitable species for fibreboard are *Toona ciliata*, and Dipterocarp species.

The demands for wood for various industrial as well as non-industrial uses are far greater than the possible supply at present levels of availability and investment. No systematic studies had been carried out to project the demand and supply of wood and wood products in India. The main objectives of the study were (1). To analyze the trends in production of wood and wood product and, (2) To assess the demand and supply of wood and wood products in the country.

Methodology

The forest products were classified into wood and wood products. The wood was further classified into round wood and industrial wood. The wood products were classified into plywood, particleboard, and fiberboard. The data on production, imports, exports, of wood and wood products were collected from 1970 to 1998 from F.A.O Year Books of Forest Products. The data on population growth rate and area of forests in India were collected from the statistical abstracts of India.

To estimate the growth rates of wood and wood products, the compound growth function was used with the following fuctional form:

$$Y = ab^t$$

$$\text{i.e.,} \quad \log y = \log a + t \log b$$

Where:

Y = production (m cum)

a= constant

b=(1+r)

r=compound growth rate.

t=time variable in years (1,2,3... 29)

In log form b was calculated by using formula

$$\log b = \frac{(\Sigma t.\ \Sigma \log_y - (\Sigma t.\Sigma \log_y)/N}{(\Sigma t^2 - ((\Sigma t)^2)/N}$$

Where,

N = Number Of years.

The Compound growth rate is given by

(Antilog of logb-1)*100

One of the objectives was quantitatively assessed with data on demand and supply of wood and wood products. In the present study demand refers to the total production plus net exports

i.e., $D = P+(I-E)$

Where,

D= demand (m cum), P=production (m cum), I=Imports quantity (m cum)

The supply refers to the total production.

i.e., $S = (P)$

Where,

S=Supply (m cum),

P=production (m cum)

The projection was estimated by the formula

$Dt = X(1+R)^T$

Where,

Dt =demand projection in 2010

X=quantity of demand at base year (1998)

R=CGR

T=difference between base year & projected year

(I.e,base year (1998)-projected year)

Result and Discussion

Major wood in India

A long-term analysis of forest products in India (Table1) indicates that growth rates would reveal a consistent increase (2.02%) without any dip (100-102.56) for round wood. The production of round wood in India has increased from 167.68 m.cum in 1970 to 299.4 m.cum. This implied that despite the ban on forest felling, the output of wood increased in India. The mean annual production of round wood was 232.86 m.cum during the period of 1970 to 1998.

In the case of industrial wood, there has also been a continuous growth rate (2.02%). The mean annual production of industrial wood was 20.9m.cum during the period of 1970 to 1998.

Major wood products in India

Table 2 indicated that the growth rate for plywood production during the period (1970-1998) was 3.04%. The annual growth rate of plywood production for the years 1972,1973,1975 and 1992 were low when compared with the base year (1970). The production of plywood in India has increased from 0.12m.cum (1970) to 0.24m.cum (1998). The mean annual production of plywood was 0.23m.cum during the period of 1970 to 1998. The mean annual export quantity (0.0129 m. cum) was greater than mean annual import quantity (0.0049 m.cum) during the period from 1970 to 1998.

The production of particleboard in India increased from 0.012m.cum in 1970 to 0.06 m. cum (1998), and its mean annual production stood at 0.035 m.cum (1970-1998). The growth in total particleboard production during (1970-1998) was 7.25%. The mean annual export quantity (0.0023 m.cum) was greater than mean annual import quantity (0.0012 m.cum) during the period from 1970 to 1998.

The production of fiberboard in India increased from 0.0304 m.cum in 1970 to 0.0357 m.cum in 1998. Moreover, its mean annual production stood at 0.0378 m.cum (1970-1998). The growth in total fiberboard production during (1970-1998) was 2.02%. The mean annual export quantity (0.0024 m.cum) was greater than mean annual import quantity (0.0017 m.cum) during the period from 1970 to 1998.

Demand-Supply of wood & wood products

Table 3 indicates that there will be serious shortages of wood and wood products for industrial and home consumption in India by 2010. In a developing country like India, the demand for forest products is growing at a rapid pace. The gap between availability and demand for wood and wood products is ever increasing. India has the second highest population in the world. The population of India was 96 crore in 1998 to 100 crore 2000. The population growth rate during this period was 2.1%, Per capita NNP is 13193 (Rs). This factor triggered the demand for wood and wood products.

Table 3 shows that the demands for of round wood and industrial wood will be 382.86 m cum and 38.42m cum by 2010, but the supply will be, 380.72 m cum and 31.98 m cum respectively. Demand is greater than the supply and the imbalance is high for industrial wood than in round wood. The demand for plywood, particleboard, and fiberboard were projected at 0.35mcum, 0.16mcum, and 0.10mcum respectively by 2010, but the supplies of these would be 0.35mcum, 0.14mcum, and 0.045mcum respectively. In the wood products, the imbalance was observed to be higher for fiberboard than particleboard and plywood.

Conclusion

The production of wood (round wood, industrial wood and firewood) showed an increasing trend. The demand for wood and wood products also showed a positive trend. The demand and supply imbalance was also projected to be high. This reveals that serious shortage of wood and products will be experienced in India.

Policy

1. To meet the demand for wood and wood products in the future the creation of tree reserves in the wastelands and the establishment of plantations of fast growing tree species are encouraged..
2. The continued technological improvements in production and marketing in the forest industries will be essential to achieve projected demands. (I.e., new techniques for peeling low girth logs should be continued for wood products, increasing efficiency in use of wood in use) ,
3. Imports of timber products are likely to increase somewhat to meet future supply
4. The investment in research in the forestry sector per ha is low now as compared with developed countries. It has to be high in the future.

References

Advisory Board on Energy 1985, Towards a perspective on Energy, Demand –supply in India in 2004-05. *Govt. of India*, New Delhi.

Chaturvedi, A.N and Khana, L.S. 1982, *Forest Mensuration* , International Book distributors, Dehradun.

FRI & colleges 1980, *The Silviculture of Indian Trees*, Vol.III Controller of publication, New Delhi.

Krishna kutty ,C.N, 1990, Demand & Supply of wood in kerala and their future trends. *KFRI Research Report* p –67

Amar s Guleria, 1988 , current production and future requirement of wood products in India, *Indian journal Agricultural economics,* Vol.43, No:3,p 270-272.

Madan Mohan Pant , 1984, Forest Economics and Valuation, Medhawi publishers, Dehradun, India. P 420-433.

CSOS statistical Abstract of various years, published by central statistical organization, New Delhi.

Metha , P.V, Plywood Industry in India , Ministry of Industries, Government of India, New Delhi.

Pant ., M.M, Forest sector – Its contribution to Gross National products, *Indian Forest*, Vol. 103,No;11,Nov.1977, P 740-769.

Swaminathan, M.S.1979. Convocation Address 29 Oct 1979, Southern Forest Rangers College, Coimbatore.

Table 1. Major wood in India.

Year	Round wood		Industrial wood	
	Production (cum)	A.G.R.I	Production (cum)	A.G.R.I
1970	167,680,992	100	12,695,000	100
1971	171,772,008	102.44	13,213,000	104.08
1972	176,154,000	102.55	13,944,000,	105.53
1973	180,667,992	102.56	14,754,000	105.81
1974	185,255,992	102.54	15,618,000	105.86
1975	189,673,008	102.38	16,313,000	104.45
1976	194,139,000	102.35	17,072,000	104.65
1977	198,400,000	102.19	17,630,000	103.27
1978	202,773,000	102.2	18,254,000	103.54
1979	207,323,000	102.24	18,944,000	103.78
1980	212,081,008	102.29	19,684,000	103.91
1981	217,043,000	102.34	20,461,000	103.95
1982	222,187,000	102.37	21,273,000	103.97
1983	227,490,000	102.39	22,122,000	103.99
1984	232,911,000	102.38	23,009,000	104.01
1985	238,418,000	102.36	23,934,000	104.02
1986	243,138,000	101.98	24,029,000	100.4
1987	247,897,008	101.96	24,124,000	100.4
1988	252,657,992	101.92	24,219,000	100.39
1989	257,379,992	101.87	24,314,000	100.39
1990	262,032,008	101.81	24,407,000	100.38
1991	266,783,992	101.81	24,501,000	100.39
1992	271,529,000	101.78	24,597,000	100.39
1993	276,256,000	101.74	24,691,000	100.38
1994	280,965,000	101.7	24,785,000	100.38
1995	285,649,992	101.67	24,879,000	100.38
1996	290,304,000	101.63	24,971,000	100.37
1997	294,920,992	101.59	25,064,000	100.37
1998	299,490,000	101.55	25,156,000	100.37
Mean annual	232861137.1		20988172	
CGR *	2.02		2.02	
M.A. IMP.QT **	345911.28		6096.55	
M.A. EXP.QT ***	20544.55		434.45	

Note: * compound growth rates.
** Mean annual import quantity.
*** Mean annual export quantity
A.G.R.I means annual growth rate index

Table 2. Major wood products in India.

Year	Plywood		Particleboard		Fiberboard	
	Production (cum)	A.G.R.I	Production (cum)	A.G.R.I	Production (cum)	A.G.R.I
1970	128000	100	11900	100	30,400	100
1971	144000	112.5	13700	115.13	28,200	92.763
1972	130000	90.28	15000	109.49	33,400	118.44
1973	126000	96.92	13200	88	30,000	89.82
1974	143000	113.5	8600	65.152	27,000	90
1975	127000	88.81	10800	125.58	24,600	91.111
1976	141000	111	13000	120.37	22,000	89.431
1977	149000	105.7	15500	119.23	25,000	113.64
1978	176000	118.1	21000	135.48	32,000	128
1979	180000	102.3	28000	133.33	32,000	100
1980	200000	111.1	31000	110.71	20,000	62.5
1981	280000	140	6,000	19.355	42,000	210
1982	300000	107.1	28000	466.67	45,000	107.14
1983	300000	100	30000	107.14	50,000	111.11
1984	360000	120	34000	113.33	46,000	92
1985	360000	100	32000	94.118	46,000	100
1986	360000	100	32000	100	50,300	109.35
1987	360000	100	32000	100	46,000	91.451
1988	290000	80.56	55700	174.06	54,800	119.13
1989	255000	87.93	54700	98.205	55,400	101.09
1990	258000	101.2	53200	97.258	49,100	88.628
1991	250000	96.9	58700	110.34	45,400	92.464
1992	231000	92.4	60000	102.21	48,000	105.73
1993	245000	106.1	60000	100	35,700	74.375
1994	245000	100	60000	100	35,700	100
1995	245000	100	60000	100	35,700	100
1996	245000	100	60000	100	35,700	100
1997	245000	100	60000	100	35,700	100
1998	245000	100	60000	100	35,700	100
MEAN ANNUAL	231655.1724		35103.483		37820.6897	
CGR*	3.04		7.25		2.02	
M.A. IMP.QT**	4893.6		1152.76		1742.59	
M.A. EXP. QT***	12909		2317.52		2041.07	
M.A. EXP. QT***						

Note:
* compound growth rates.
** Mean annual import quantity.
*** Mean annual export quantity
A.G.R.I means annual growth rate index

Table 3. Demand and supply imbalances for wood and wood products in India.

Forest products	Projection 2010 (m. cum)		Imbalance (per cent)
	Demand	Supply	
WOOD			
1.Round wood	382.861	380.720	-0.55921
2.industrial round wood	38.422	31.97904	-16.7689
wood products			
1.ply wood	0.380451	0.350943	-7.75606
2.particle board	0.1632	0.1389	-14.89
3.fibre board	0.102418	0.045383	-55.6885

NOTE: Percent imbalance = $(St-Dt/Dt)*100$

$Dt = X(1+R)^T$

Where,

Dt =demand projection in 2010

X=qty.of demand at base year (1998)

R=CGR (compound growth rate)

T=difference between base year & projected year

(I.e., Base year (1998)-projected year (2010))*

Influence of Different Potting Mixtures on Germination and Seedling Growth of *Acacia nilotica* ssp. *indica*

A. Venkatesh [1], K. Vanangamudi [2] and R. Umarani [3]
[1]Central Agricultural Research Institute, Port Blair – 744 101, A & N Islands
[2]Department of Seed Science & Technology, TNAU, Coimbatore – 641 003, TN
[3]Forest College & Research Institute, TNAU, Mettupalayam - 641 301, TN

Abstract

The acid scarified (60 min.) seeds of *Acacia nilotica* ssp. *indica* were sown in potting mixture containing: i) red soil: sand: FYM, ii) red soil: sand: vermicompost, iii) red soil: sand: goat manure, iv) red soil: sand: poultry manure, v) red soil: sand: sago waste, vi) red soil: sand: sand, vii) red soil: sand: vermiculite, viii) red soil: sand: leaf litter compost, ix) red soil: sand: raw coir pith at 2:1:1 ratio in order to identify a suitable potting mixture. Based on the results, seeds of *Acacia nilotica* ssp. *indica* subjected to pretreatment should be sown in red soil: sand: goat manure ratio potting mixture, in order to get higher germination percentage and better seedling vigour.

Key words: *Acacia nilotica*, potting mixture, germination, seedling vigour

Introduction

Acacia nilotica (L.) Willd. subsp. *indica* Benth. commonly known as Babul, Indian Gum – Arabic tree or Karuvel belongs to the subfamily Mimosoidae, family Fabaceae. It is a medium sized tree, can reach heights of 20 m and a diameter of 60-80 cm, but is commonly limited by site quality to heights of 10 m or less. It is an important multipurpose tree widely used for fuel wood (calorific value of 4950 Kcal kg^{-1}), fodder (contain 8% digestible protein in pods and leaves), timber (specific gravity of 0.67-0.80, weight 830 kg cm^{-3}, strong, durable, nearly twice as hard as teak and shock resistant), tannin (green pods have 30% and bark 20%) and gum. It is mainly used for afforestation of dry areas, not only in the Indian sub continent (Troup, 1986) but also in Africa (Dwivedi, 1993). This species has been widely planted and distributed in semi-arid regions of Pakistan (Ahmad, 1937), in Sudan and other African countries (Bowen, 1988).

The ideal potting mixture to raise seedling needs to be light, but not bulky and should contain adequate nutrients. The components of potting mixture used vary considerably from country to country and depending on the species to be raised (Laurie, 1974). The present investigation was made to find suitable potting mixture for seed germination and growth of *Acacia nilotica* subsp. *indica*

Materials and Methods

In order to identify a suitable potting mixture for raising elite seedling, the following potting mixture combinations were evaluated. The acid scarified (60 min) seeds were sown in potting mixture containing: i) red soil: sand: FYM [farm yard manure]; ii) red soil: sand: vermicompost; iii) red soil: sand: goat manure; iv) red soil: sand: poultry manure; v) red soil: sand: sago waste; vi) red soil: sand: sand; vii) red soil: sand: vermiculite; viii) red soil: sand: leaf litter compost and; ix) red soil: sand: raw coir pith at 2:1:1 ratio. The design followed for this study was CRD with three replications at 25 containers each.

One month after sowing, germination counts were made and expressed as the percentage of seeds which produced normal seedlings (ISTA, 1993). After the germination count, twenty random seedlings were measured for their shoot and root length, and vigour index was computed following Abdul - Baki and Anderson (1973) as:

Vigour index = Germination (%) x seedling length (cm)

Subsequently, the seedlings were kept in an oven maintained at 80°±1° for 24 h and the samples were cooled in a desiccator for 30 min, weighed and expressed in mg seedlings^{-3}. The observations were recorded on 1, 3 and 5 months after sowing on five random seedlings. The results were subjected to analysis of variance and tested for significant differences (Panse and Sukhatme, 1978).

Results and Discussion

At one month after sowing

The germination was higher in red soil : sand: goat manure (98.0 per cent). The lower germination was observed in red soil : sand : FYM (88.7 per cent). Potting mixture containing red soil : sand : goat manure performed well by registering a shoot length of 24.9 cm. Shorter shoot (11.5 cm) was recorded in red soil : sand : sago waste. Potting mixture of red soil : sand : FYM recorded a shoot length of 21.2 cm. The highest root length of 31.6 cm was observed in potting mixture containing red soil : sand : goat manure, whereas it was the shortest in red soil : sand : sand (18.1 cm). The root length of 28.5 cm was recorded by red soil : sand : FYM mixture. The vigour index was more (5,544) in red soil : sand : goat manure and less (2,888) in red soil : sand : sand. Whereas it was 4,419 in red soil : sand : FYM potting mixture. Seedlings obtained from red soil : sand : goat manure registered the highest dry matter production (2.831 g seedlings^{-3}), while it was less in red soil : sand : vermiculite (1.014 g seedlings^{-3}). The mixture of red soil : sand : FYM recorded a value of 2.687 g seedlings^{-3} (Table 1).

At three months after sowing

Longer shoot of 71.9 cm was recorded in red soil : sand : goat manure, while shorter shoot in red soil : sand : vermiculite (37.8 cm). Red soil : sand : FYM mixture registered a shoot length of 58.4 cm. The root length was more (35.7 cm) in red soil : sand : goat manure and less (28.6 cm) in red soil : sand : FYM mixture. The biggest shoot collar diameter was observed in potting mixture containing red soil : sand : goat manure (4.9 mm), while the smallest in red soil : sand : raw coirpith (3.5). The red soil : sand : FYM mixture recorded a shoot collar diameter of 3.8 mm. The shoot and root dry weights were more in potting mixture of red soil : sand : goat manure (17.062 and 4.613 g seedlings^{-3}, respectively). Whereas, less shoot dry weight of 4.443 g seedlings^{-3} in red soil : sand : vermiculite and root dry weight of 2.173 g seedlings^{-3} in red soil : sand : raw coirpith were recorded. Mixture of red soil : sand : FYM registered 9.430 and 3.676 g seedlings^{-3}, respectively. Seedlings produced from the mixture containing red soil : sand : goat manure recorded more dry matter production (21.675 g seedlings^{-3}). It was less in red soil: sand : vermiculite (6.972 g seedlings^{-3}), which was on par with red soil : sand : raw coirpith (6.976 g seedlings^{-3}) mixture. Red soil : sand : FYM mixture recorded a dry matter production of 13.106 g seedlings^{-3} (Table 2).

At five months after sowing

Red soil : sand : goat manure registered the longest shoot of 79.3 cm, while the shortest in red soil : sand : sand (52.1 cm) which was at par with red soil : sand : raw coirpith (54.1 cm) and red soil : sand : vermiculite (54.8 cm). Red soil : sand : FYM recorded a shoot length of 63.3 cm. Root length was more in the seedlings grown in red soil : sand : goat manure (41.5 cm) and less in red soil : sand : leaf litter (32.5 cm). Mixture of red soil : sand : FYM recorded a root length of 35.1 cm The highest shoot collar diameter was recorded in red soil : sand : goat manure (6.1 mm) g, while the lowest in red soil : sand : leaf litter (4.2 mm). Red soil : sand : FYM mixture produced the seedlings with 4.8 mm shoot collar diameter . More shoot (17.966 g seedlings^{-3}) and root (9.836 g seedlings^{-3}) dry weights were recorded in red soil : sand : goat manure mixture while it was the least in red soil : sand : raw coirpith (10.772 and 4.259 g seedlings^{-3}, respectively). Red soil : sand : FYM mixture recorded 11.965 and 6.352 g seedlings^{-3}, respectively. The highest dry matter production of 27.802 g seedlings^{-3} was recorded by red soil : sand : goat manure mixture, while the lowest in red soil : sand : raw coirpith (15.031 g seedlings^{-3}). Red soil : sand : FYM mixture recorded 18.317 g seedling^{-3} (Table 3). The observation made at regular intervals viz., first, third and fifth month after sowing revealed that red soil: sand: goat manure at 2:1:1 ratio is superior to rest of the potting mixtures.

It is in conformity with the results of Natarajan (1999) in *Albizia lebbeck* and Venkatesh et al. (1999) in *Casuarina equisetifolia* seedlings. The increase in growth attributes was recorded in *Eucalyptus tereticornis* in sand medium (Vinaya Rai et al., 1980); *Acacia* in decomposed leaf compost:loamy soil at 1:4 ratio (Roy

et al., 1985); *Gmelina arborea, Dalbergia sissoo* and *Dendrocalamus strictus* in sand, soil and pressmud at 2:1:4 ratio (Vashista et al., 1977).

Red soil is best suited for *Eucalyptus* and some *Acacias* (Shetty, 1977) and *Azadirachta indica, Anona squamosa, Syzigium cuminii* and *Eucalyptus globulus* (Malewar et al., 1998). Singh (1982) concluded that pulverized soil and coirpith in 2:1 ratio performed better for *Acacia* spp. *Leucaena leucocephala* and *Prosopis* spp.

The relative pore space of growing medium affects seedling growth and development in containers. Properly balanced pore spaces provide good gaseous exchange for the root system and directly affect water and mineral nutrient uptake (Dhiman and Sood, 1994).

Based on the results of the present experiment it is recommended, seeds of *Acacia nilotica* ssp. *indica* subjected to pretreatment should be sown in red soil: sand: goat manure ratio potting mixture, in order to get higher germination percentage and better seedling vigour.

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science* Vol 13 pp 360-363.

Ahmad, G. 1937. Contour bunds, their finances and effect on growth. *Pakistan Journal of Forestry* Vol 7 No 2 pp 151-153.

Bowen, M.R. 1988. A. Survey of tree planting in Somalia 1925-1985. OFI occasional papers, Oxford Forestry Institute, Oxford University, No. 36. 44 pp.

Dhiman, R.C and Sood, S.K. 1994. Trials with different root trainers and potting media. In: Proceedings of *'Seminar on root trainer seedling production system'* (ed. K. Subramanian and M. Jha). Pune. Oct. 6, p. 35-39.

Dwivedi, A.P. 1993. Babul (*Acacia nilotica*). A multipurpose tree of dry areas. Scientific Publishers, Jodhpur. 69 pp..

ISTA. 1993. International rules for seed testing. *Seed Science & Technology* Vol 21 pp 1-288.

Laurie, M.V. 1974. *Tree planting practices in African Savannas*. FAO Forestry Development Paper No. 19. FAO, Rome.

Malewar, G.V., P.B. Adsul and S. Ismail. 1998. Effect of different combinations of flyash and soil on growth attributes of forest and dryland fruit crops. *Indian Journal of Forestry* Vol 21 No 2 pp 124-127.

Natarajan, S. 1999. Investigations on seed source variations, standardization of seed testing procedures and nursery techniques in *Albizia lebbeck* (L.) Benth. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Panse, V.G. and Sukhatme, P.V. 1978. *Statistical Methods for Agricultural Workers*. ICAR., New Delhi. 327 pp.

Roy, M.M., J.L. Karihaloo and R. Del Roy. 1985. Seedling growth and performance in field conditions in some fodder Acacias. Journal of Tree Science Vol 4 No 1 pp 49-53.

Shetty, B. 1977. Social forestry in Tamil Nadu. *Indian Forester* Vol 26 No 11 p 82.

Singh, R.V. 1982. Fodder trees of India. Oxford and IBH Publishing Co., New Delhi, Bombay and Calcutta, 14 & 21.

Troup, R.S. 1986. *The Silviculture of Indian Trees*. Vol. II Leguminosae. Intonational Book Distributors, Dehra Dun and Nazia Printers, Delhi - 110 006, pp. 418-447.

Vashista, S., Kukadia, M.U., Vashi, B.G. and Jadeja, D.B. 1997. Effect of various potting mixtures and fertilizers on the germination and growth of agroforestry tree species in the nursery stage. *Journal of Tropical Forestry* Vol 13 No II pp 112-116.

Venkatesh, A., Umarani, R. and Vanangamudi, K. 1999. Effect of different potting mixtures on growth attributes of *Casuarina equisetifolia*. In: National Symposium on Forestry Towards 21st Century, Forest college and Research Institute, Mettupalayam - 641 301, Sep. 27-28. p. 92.

Vinaya Rai, R.S., Krishnaswami, S. and Rangaswami, A. 1980. Studies on optimum nursery medium and use of graded seeds in *Eucalyptus tereticornis*. *South Indian Journal of Horticulture* Vol 28 No 4 pp 143-146.

Table 1. Effect of potting mixtures on germination and seedling growth attributes of *A. nilotica* at one month after sowing

Potting mixturesat 2:1:1	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index	Drymatter production (g/seedlings^{-5})
Red soil : Sand : FYM	88.7 (70.3)	21.2	28.7	4419	2.687
Red soil : Sand : Vermicompost	92.7 (74.3)	15.1	28.4	4027	2.249
Red soil : Sand : Goat manure	98.0 (83.4)	24.9	31.6	5544	2.831
Red soil : Sand : Poultry manure	96.7 (79.6)	18.7	25.3	4253	2.242
Red soil : Sand : Sago waste	92.0 (73.7)	11.5	23.4	3213	1.361
Red soil : Sand : Sand	94.0 (76.0)	12.6	18.1	2888	1.891
Red soil : Sand : Vermiculate	96.7 (79.6)	12.9	23.8	3555	1.014
Red soil : Sand : Leaf litter	95.3 (77.6)	16.4	25.9	4035	2.414
Red soil : Sand : Raw coir pith	96.7 (79.6)	14.5	25.7	3885	2.318
Mean	94.5 (77.1)	16.4	25.6	3980	2.118
Sed	2.15	0.42	0.55	73.2	0.156
CD (P=0.05)	4.32	0.88	1.15	153.8	0.329

Table 2. Effect of potting mixtures on growth attributes of *A. nilotica* at 3 months after sowing

Potting mixtures at 2:1:1	Shoot length (cm)	Root length (cm)	Shoot collar diameter (mm)	Shoot dry weight (g seedlings $^{-3}$)	Root dry weight (g seedlings $^{-3}$)	Drymatter production (g seedling^{-3})
Red soil : sand : FYM	58.4	28.6	3.8	9.430	3.676	13.106
Red soil : Sand : Vermicompost	49.5	32.7	3.8	12.105	4.467	16.572
Red soil : Sand : Goat manure	71.9	35.7	4.9	17.062	4.613	21.675
Red soil : Sand : Poultry manure	49.1	34.6	4.2	9.790	2.809	12.599
Red soil : Sand : Sago waste	48.7	33.8	4.0	8.622	2.683	11.305
Red soil : Sand : Sand	41.7	30.8	3.9	7.857	3.097	10.954
Red soil : Sand : Vermiculite	37.8	31.2	3.8	4.443	2.529	6.972
Red soil : Sand : Leaf litter	47.4	35.3	4.3	8.994	3.943	12.937
Red soil : Sand : Raw coirpith	45.6	29.4	3.5	4.803	2.173	6.976
Mean	50.0	32.4	3.9	9.234	3.332	12.566
Sed	1.73	1.20	0.17	0.2052	0.0379	0.2431
CD (P=0.05)	3.64	2.52	0.36	0.4310	0.0797	0.5112

Table 3. Effect of potting mixtures on growth attributes of *A. nilotica* at 5 months after sowing

Potting mixtures @ 2:1:1	Shoot length (cm)	Root length (cm)	Shoot collar diameter (mm)	Shoot dry weight (g seedlings^{-3})	Root dry weight (g seedlings^{-3})	Dry matter production (g seedling^{-3})
Red soil : sand : FYM	63.3	35.1	4.8	11.965	6.352	18.317
Red soil : Sand : Vermicompost	65.3	36.9	4.9	14.12	7.705	21.832
Red soil : Sand : Goat manure	79.3	41.5	6.1	17.966	9.836	27.802
Red soil : Sand : Poultry manure	61.7	36.4	5.2	14.058	6.622	20.680
Red soil : Sand : Sago waste	64.0	36.2	4.6	11.286	6.705	17.991
Red soil : Sand : Sand	52.1	37.3	4.9	13.957	5.994	19.951
Red soil : Sand : Vermiculite	54.8	34.6	4.9	10.886	6.728	17.614
Red soil : Sand : Leaf litter	57.1	32.5	4.2	11.100	6.566	17.666
Red soil : Sand : Raw coirpith	54.1	36.1	4.3	10.772	4.259	15.031
Mean	61.3	36.1	4.9	12.902	6.752	19.654
Sed	1.79	0.97	2.1	0.1593	0.0562	0.2155
CD (P=0.05)	3.76	2.05	4.5	0.3346	0.1185	0.4531

Screening the Best Seed Source for Obtaining High Quality Seed and Seedlings of *Acacia nilotica* (L.) Willd. subsp. *indica* Benth.

A. Venkatesh [1], K. Vanangamudi [2] and R. Umarani [3]
[1]Central Agricultural Research Institute, Port Blair – 744 101, A & N Islands
[2]Department of Seed Science & Technology, TNAU, Coimbatore – 641 003, TN
[3]Forest College & Research Institute, TNAU, Mettupalayam - 641 301, TN

Abstract

The best seed source to procure good quality seeds of *Acacia nilotica* ssp. *indica* was studied. The seeds were collected from plus trees located in four seed zones viz., Vellore, Tirupattur, Tiruvanamalai (North eastern zone), Salem, Dharmapuri (North western zone), Erode, Coimbatore, Aliyar (Western zone), Virudhunagar, Kovilpatty, Madurai, Paramakudi, Cumbum, Periyakulam (Southern zone) were used in this investigation. The evaluation of seed source for high quality seed production indicated that physical characteristics of seeds viz., seed thickness and hundred seed weight was more in Coimbatore (Western zone), while they were less in Vellore (North eastern zone) and Kovilpatty (Southern zone), respectively. Kovilpatty (Southern zone) for seed length and Virudhunagar (Southern zone) for seed width showed higher values. Seed length and seed width were minimum in Salem (North western zone) and Periyakulam (Southern zone) seed source, respectively. The insect (*Bruchus sparimalatus*) damage was less in Paramakudi and more in Virudhunagar of Southern zones. Considering the growth attributes of seedlings viz., shoot length, root length, shoot collar diameter, root volume, number of branches and dry weight, the same seed sources performed better over the rest of the sources. The performance of out planted seedlings in the field, sixteen months after planting showed the superior performance of seedlings from Tirupattur (North eastern zone) in terms of seedling survival percentage and other growth parameters. The performance of seedlings from Salem (North western zone) seed source in the field was poor.

Introduction

Acacia nilotica (L.) Willd. subsp. *indica* Benth., commonly known as Babul, is an important multipurpose tree widely used for fuelwood (calorific value of 4950 Kcal kg^{-1}), fodder (contain 8% digestible protein in pods and leaves), timber (specific gravity of 0.67-0.80, weight 830 kg cm^{-3}, strong, durable, nearly twice as hard as teak and shock resistant), tannin (green pods have 30% and bark 20%) and gum. This species can survive under different conditions of rainfall, particularly in region where rainfall varies between 50-1250 mm (Champion and Seth, 1968). In its natural range of distribution, *A. nilotica* can withstand high temperature variations ranging from 40-45°C (Bharucha, 1951). It is mainly used for afforestation of dry areas, not only in the Indian sub continent (Troup, 1986) but also in Africa (Dwivedi, 1993). This species has been widely planted and distributed in semi-arid regions of Pakistan (Ahmad, 1937), in Sudan and other African countries (Bowen, 1988).

Seeds are influenced by their origin (Heydecker, 1972) particularly due to environmental variations in latitude, altitude, rainfall, temperature, moisture, soil, day length and other external factors (Padmini and Banerjee, 1986). The seed source variation was reported on many tree species (Gera *et al* 1999; Vasudeva *et al* 1999; Masilamani *et al* 1999) and is dictated by environmental and edaphic factors. This may also be due to altitudinal variation (Barnett and Farmer, 1978) or region of collection (Bonner, 1984). Hence, the best provenance has to be selected to choose the best available sources for seed collection.

The physical characteristics of the seeds collected from various sources show polymorphism in physical measurements and weight. The physical measurements are important as they have an indirect bearing on seed quality. Seeds of almost all tree species are prone to damage insects, fungi and bacteria, while they are borne on the tree (Bedell, 1998). The insect damage affects seed germination in *Albizia lebbeck* (Ponnusamy et al., 1990). Satya Vir and Jindal (1997) also reported 48, 46 and 20 per cent insect damage in *Prosopis*

cineraria, A. lebbeck and *Acacia senegal,* respectively. Assessment of the damage caused by insects will be helpful in calculating the quantity of seed required to produce planting stocks for the plantations.

It is hence essential to evaluate not only the physical and physiological quality of the seedling but also to study the performance of different seed sources under nursery conditions to ascertain the source effect to select the best suited source. Field trials are important to know the survival potential of sources (Indra and Basha, 1999).

Materials and Methods

The seeds of karuvel (*Acacia nilotica* ssp. *indica*) were collected from the identified superior trees located at fourteen seed sources in four agroclimatic zones of Tamil Nadu (Table 1).The variation in physical and physiological quality of seeds collected from different seed sources were studied. The experiment was set up in a Completely Randomized Design (CRD) with four replications.

Seed quality

Ten seeds from each source were selected at random to measure the following physical characteristics: *i) Seed length :* The length of seed from the base to the tip was measured using Vernier Caliper and expressed in millimeter; *ii) Seed width :* The width at the middle of the seed was measured using Vernier Caliper and expressed in millimeter; *iii) Seed thickness* : The thickness at the middle of the seed was measured using Vernier Caliper and expressed in millimeter; *iv) Insect damaged seed :* One hundred seeds in four replications were taken from each seed source and the number of insect damaged seeds was counted. The percentage was computed as follows.

$$\text{Insect damaged seed (\%)} = \frac{\text{Number of insect damaged seeds}}{\text{Total number of seeds}} \times 100$$

v) Hundred seed weight: Measurement of seed weight was made on the pure seed component of the purity test and weight was normally expressed as the weight of 100 pure seeds. As per ISTA rules (1993), eight replications of 100 seeds each were counted and weighed from the fourteen seed lots. The standard deviation and coefficient of variation were calculated. When the coefficient of variation is below 4, then the samples are judged as homogenous as per ISTA (1993) standards.

Seedling quality

The seeds from fourteen different seed sources were scarified using commercial grade H_2SO_4 at 600 ml kg^{-1} of seed for 60 min and washed thoroughly in running tap water to remove the acid residues. The seeds were then soaked in cold water for 24 h. The pretreated and presoaked seeds were sown in polybags (15x25 cm size) filled with a potting mixture containing red soil, sand and farmyard manure in a proportion of 2:1:1 ratio. The experiment was set up in CRD with four replications of one hundred seeds each. The seedlings were raised as per standard nursery practices. The following growth parameters on ten randomly-selected seedlings were observed six months after sowing: *i) Root length*: The seedlings were removed from the polybags without damaging the root and washed thoroughly to remove the adhering soil particles. The root length was measured from the collar region to the tip of the primary root using meter scale and expressed in centimeter; *ii) Shoot length* : The shoot length was measured from the root collar to the growing tip of the seedling using meter scale and expressed in centimeter; *iii) Shoot collar diameter* : The diameter of the shoot at the root collar was measured using a vernier caliper and expressed in centimeter; i*v) Root volume* : By water displacement method and expressed in cc; *v) Number of branches* :The number of leaves in each of the seedling was counted; *vi) Root and shoot dry weights* : The root and shoot were separately dried under the shade for few hours and then dried in a hot air oven maintained at 80 ± 1°C for 24 ± 1 h. After drying, the materials were cooled in a desiccator for 30 min., weighed in g; *vii) Drymatter production* : The dry matter production of the seedling was arrived at by adding root and shoot dry weights and expressed in g.

Field survival percentage

The six month-old seedlings grown from fourteen seed sources were field planted using a spacing of 3 x 3 m in a RBD, replicated three times. The observations viz., survival percentage, plant height, shoot collar diameter and number of branches on five randomly-selected seedlings were recorded 16 months after planting. The results were subjected to analysis of variance and tested for significant differences (Panse and Sukhatme,1978).

Results and Discussion

Seed quality

The present investigation revealed that the seed length (8.3 mm) was more in Kovilpatty, while it was less (7.5 mm) in Salem. Virudhunagar source ranked first for seed width (7.2 mm) and Coimbatore for seed thickness (4.0 mm) while lower values were obtained in Periyakulam (5.6 mm) and Vellore (3.4 mm), respectively. The hundred seed weight was more in Coimbatore (15.21 g) and less in Kovilpatty (11.36 g) (Table 2).

Similar variations in physical parameters due to sources were reported in *Tectona grandis* (Manonmani and Vanangamudi 1997; Masilamani et al., 1999), *Santalum album* (Sindhuveerendra *et al* 1999), Azadirachta indica (Sindhu, 1995), *Albizia lebbeck* (Natarajan, 1999), *Emblica officinalis, Syzygium cuminii* and *Zizyphus mauritiana* (Srimathi 1997), and *Acacia nilotica* (Vanangamudi *et al.*, 1998; Bagchi, 1999). The variation in morphological characters of seeds of *Acacia* has been reported by Mathur *et al* (1984).

The insect damage by *Bruchus sparsimaculatus* was less (0.58 per cent) in Paramakudi and high (11.07 per cent) in Virudhunagar seed source. The insect damage by the bruchid (*B. sparsimaculatus*) was reported in seeds of *Albizia lebbeck* (Bedell, 1998; Natarajan, 1999) *Prosopis cineraria* and *Acacia senegal* (Satya Vir and Jindal, 1997).

Seedling quality

The study of seed physical characters has to be correlated with the physiological potential of the seeds. It includes germination potential, seedling performance in nursery and field, which can serve as the sound basis to delineate the best seed source(s). Hence, a detailed study was planned to study the physiological potential of the seeds collected from various sources.

Tirupattur (83.0 cm) followed by Vellore (82.5 cm) and Salem (81.3 cm) showed better performance six months after sowing. Longer root length was registered by Tirupattur (32.4 cm) followed by Vellore (31.0 cm), Cumbum (29.5 cm) and Madurai (29.0 cm). Seedlings evaluated 6 months after sowing revealed more shoot length (83.0 cm), root length (32.4 cm), root volume (5.0 cc), number of branches (6.5) and dry matter production (9.402 g seedlings^{-5}) were observed in Tirupattur of North eastern zone. Most of the traits were at par with Vellore (Table 3).

Variation in root and shoot lengths, and vigour index due to seed source was also reported in *Acacia nilotica* by Vanangamudi *et al* (1998). Wide variation among provenances and in between the growth stages were also reported in *Tectona grandis* (Manonmani and Vanangamudi 1997), *Albizia falcataria* and *Leucaena leucocephala* (Palit 1980), *Pinus* sp. (Ghosh *et al* 1981), *Eucalyptus camaldulensis* (Ghosh *et al* 1977) and *Populus* sp. (Jha *et al* 1991).

Field survival percentage

After evaluating the seedling growth performance in the nursery, the seedlings were outplanted and observed for their survival and growth out in the field. Tirupattur, Vellore and seed sources recorded the highest (73 per cent) survival percentage in the field while Periyakulam recorded the lowest survival percentage (59 per cent). Evaluation of seedlings in the field sixteen months after planting showed higher plant height (327.5 cm), shoot collar diameter (6.0 cm) and number of branches (243) in Tirupattur seed source. Salem seed source recorded lower values of 151.0 cm, 2.2 cm and 82, respectively (Table 4). Similar variation in growth characteristics among seed sources was observed in *Pinus taeda* (Wells and Wakeley 1966), *Pinus kesiya*

(Chamshama *et al* 1999), *Pinus patula* (Paudel *et al* 1996), Acacia spp. (Maghembe and Chirwa 1997), *Calliandra calothyrsus* (Triwahyono and Mimber 1991) and *Acacia mangium* (Lawskul 1991).

The seed physical characteristics observed for *A. nilotica* varied significantly. More seed length in Kovilpatty, seed width in Virudhunagar, seed thickness and hundred seed weight in Coimbatore seed source.

From an holistic view, the observation on seed physical characters viz., seed length, width and thickness; physiological characters recorded in the nursery viz., seedling height, shoot collar diameter, root volume, number of branches and dry matter production and those recorded in the field viz., survival percentage, plant height, shoot collar diameter and number of branches, revealed that Tirupattur is the best seed source for collecting high quality seeds of North eastern zone among the four agro climatic zones tested in Tamil Nadu.

References

Ahmad, G. 1937. Contour bunds, their finances and effect on growth. *Pakistan Journal of Forestry* Vol 7 No 2 pp 151-153.

Bagchi, S.K. 1999. Seed source variation in *Acacia nilotica*: Genetic divergence in 18 month old seedlings. *Ann. For* 7(1): 45-55.

Barnett, P.E. and Farmer, R.E. 1978. Altitudinal variation in germination characteristics of yellow poplar in the Southern Appalachians. *Silvae Genetica* Vol 27 No 3-4 pp 101-104.

Bedell, P.E. 1998. Seed Science and Technology (Indian Forestry Species). Allied Publishers Ltd. New Delhi. 346 pp.

Bharucha, D.R. 1951. Working plan for East Khandesh Babul Forest. Forest Department, Bombay.

Bonner, F.T. 1984. Glossary of Seed Germination Terms for Tree Seed Workers, USDA Forest Service. Gen. Tech. Rep. Southern Forest Experiment Station, Starkville, Mississippi, USA, pp. 30-49.

Bowen, M.R. 1988. A. Survey of tree planting in Somalia 1925-1985. OFI occasional papers, Oxford Forestry Institute, Oxford University, No. 36. 44 pp.

Champion, H.G. and Seth, S.K. 1968. General Silviculture for India. Manage Publishers, Delhi, 511 pp.

Chamshama, S.A.O., Chingonikaya, E.E., Iddi, S. and Mugasha, A.G. 1999. Survival, growth and wood density of *Pinus kesiya* provenances of Buhinidi, Mwanza, Tanzania. *Journal of Tropical Forest Science* Vol 11 No 2 pp 401-409.

Dwivedi, A.P. 1993. Babul (*Acacia nilotica*). A multipurpose tree of dry areas. Scientific Publishers, Jodhpur. 69 pp..

Gera, M., Gera, N. and H.S. Ginwal. 1999. Seed source variation in germination and early growth among ten indigenous populations of *Dalbergia sissoo* Roxb. *Indian Forester* Vol 125 No 12 pp 1190-1197.

Ghosh, R.C., B. Singh and K.K. Sharma. 1981. Suitability trials of different species and provenances of Pines in the Doon Valley of India. *Indian Forester* Vol 107 No3 pp 135-150.

Ghosh, R.C., Gupta, B.N. and Shedha, M.D. 1977. Provenance trial of *Eucalyptus camaldulensis* Dehn. *Indian Forester* Vol 103 No 7 pp 441-453.

Heydecker, W. 1972. Vigour In: *"Viability of Seeds"*, (ed. E.H. Roberts). Chapman Hall. Londen pp. 209-252.

Indira, E.P. and Basha, S. C. 1999. Effect of seeds from difference sources on germination and growth in teak (*Tectona grandis* L.F.) nursery. *Annals of Forestry* Vol 7 No 1 pp 39-44.

ISTA. 1993. International rules for seed testing. *Seed Science. & Technology* Vol 21 pp 1-288.

Jha, K.K., Gupta, C. and Verma, R.S. 1991. Field testing of few promising clones of poplar in terai. *Indian Journal of Forestry* Vol 14 pp 83-89.

Lawskul, S. 1991. Provenance trials of *Acacia mangium* willd. at lad krating plantation, Chachoengsao, M.Sc. Thesis, Bangkok graduate school, Thailand.

Manonmani, V. and K. Vanangamudi. 1997. Investigations on seed source variation in teak (*Tectona grandis*). In: National symposium on Natural resources management system, St. Joseph's College, Trichy, February 26-28.

Masilamani, P., Dharmalingam, C. and Annadurai, K. 1999. Seed source variation in seed and seedling attributes of teak (*Tectona grandis* Linn. f). In: National Symposium on Forestry Towards 21st Century, Forest college and Research Institute, Mettupalayam - 641 301, Sep. 27-28. p. 95.

Mathur, R.S., Sharma, K.K. and Rawat, M.M.S. 1984. Germination behaviour of various provenances of *Acacia nilotica* ssp. *indica. Indian Forester* Vol 111 pp 435-449.

Natarajan, S. 1999. Investigations on seed source variations, standardization of seed testing procedures and nursery techniques in *Albizia lebbeck* (L.) Benth. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Padmini, S. and Banerjee, A.C. 1986. Provenance trials of *Acacia nilotic*a. *Journal of Tree Science* Vol 5 pp 53-56.

Palit, S. 1980. Trials of *Albizia falcataria* (L.) Foseberg and *Leucaena leucocephala* (Lam.) De Wit. in North Bengal. *Indian Forester* Vol 106 No 7 pp 456-465.

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers. ICAR., New Delhi. 327 pp.

Paudel, K.C., Amatya, S.M. and Harrison, A. 1996. Provenance trial of *Pinus maximinoii* and comparison with *Pinus wallichiana* and *Pinus patula. LARC working paper (Nepal) ISSN 1023-3393* No. 96/38.

Ponnusamy, A.S., Surendren, C. and Parameswaran, S. 1990. Effect of insect damage on seed germination in *Albizia lebbek. Indian For* 116 (6): 509-510.

Satya Vir and Jindal, S.K. 1997. Bruchids threat to quality seed production in leguminous trees. In: IUFRO symposium on *"Innovations in Forest Tree Seed Science and Nursery Technology"*, November 22-25, Pt. Ravishankar Shukla University, Raipur, India. p. 81.

Sindhu, V.H.C. 1995. Variation studies in provenances of *Azadirachta indica. Indian Forester* Vol 11 pp 1053-1056.

Sindhuveerendra, H.C., Ramalakshmi, S. and Mallesha, B.B. 1999. Variation in seed characteristics in provenances of sandal (*Santalum album* L.). *Indian Forester* Vol 125 No 3 pp 308-312.

Srimathi, P. 1997. Research focus on seed collection, processing and storage of amla (*Emblica officinalis.* Gaertn.) jamun (*Syzygium cuminii* Skeels.) and ber (*Zizyphus mauritiana* Lamk). Ph.D, Thesis, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Triwahyono, R.M.Y. and Mimbar, S.M. 1991. Effect of duration of seed water soaking in any types of planting media on seedling growth of *Calliandra calothyrsus* Meisn. *Jurnal Institute Pertanian Malang* Vol 1 No 2 pp 52-54.

Troup, R.S. 1986. The Silviculture of Indian Trees. Vol. II Leguminosae. Intonational Book Distributors, Dehra Dun and Nazia Printers, Delhi - 110 006, pp. 418-447.

Vanangamudi, K., Umarani, R., Bharathi, A. and Venkatesh, A. 1998. Effect of seed source on physical and physiological qualities of *Acacia nilotica* seeds. *Seed Research* Vol 26 No 2 pp 114-116.

Wells, O.O. and P.C. Wakeley. 1966. Geographic variation in survival, growth and fusiform- Must infection of planted loblolly pine. *Forestry Science Monograph* No 11.

Table 1. Basic site information about the different seed sources of *A. nilotica*.

Seed source	Latitude	Longitude	Rainfall	Geology & Soil	pH
North eastern zone			1137	Low level laterite	5.6
Vellore	12° 9' N	79° 0' E			
Tirupattur	10°1' N	78°0' E			
Tiruvanamalai	12°2' N	79°0'E			
North western zone			685-852	Red loam, Red non-calcareous	6.7-8.5
Salem	11°39' N	78°12' E			
Dharmapuri	12°1' N	75°0' E			
Western zone			612-1299	Granite – Gnesis, Precambiam, Cambiam	6.5-8.4
Erode	11°27' N	77°41' E			
Coimbatore	11° 1' N	76° 58' E			
Aliyar	10° 39' N	77° 0'E			
Southern zone			690-1172	Red loam, mixed black and red, brown calcareous	6.5-8.2
Paramakudi	9°21' N	78° 22' E			
Cumbum	10° 5' N	79°0' E			
Periyakulam	10°18' N	77°85' E			
Virudhunagar	9°5' N	77°0' E			
Kovilpatty	9°12' N	78°25' E			
Madurai	9°9' N	78°0' E			

Table 2. Evaluation of physical characteristics and insect damaged seeds of *A. nilotica* collected from different seed sources.

Seed source	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Insect damaged seed (%)	100 seed weight (g)
North eastern zone					
Vellore	8.2	6.7	3.4	1.46	13.48
Tirupattur	8.1	6.7	3.8	4.91	14.36
Tiruvanamalai	7.6	6.4	3.7	0.73	12.72
North western zone					
Salem	7.5	6.3	3.4	2.61	12.39
Dharmapuri	8.2	6.3	3.4	3.20	14.38
Western zone					
Erode	7.7	6.4	3.9	2.73	14.52
Coimbatore	8.2	6.9	4.0	3.07	15.21
Aliyar	7.6	6.6	3.8	2.86	13.17
Southern zone					
Virudhunagar	7.8	7.2	3.9	11.07	13.81
Kovilpatty	8.3	6.9	3.8	2.14	11.36
Madurai	8.2	7.1	3.8	9.95	11.84
Paramakudi	7.7	6.7	3.8	0.58	12.00
Cumbum	7.6	6.5	3.8	8.62	11.93
Periyakulam	7.6	5.6	3.6	6.03	12.45
Mean	7.9	6.6	3.7	4.28	13.11
SEd	0.30	0.23	0.17	1.79	CV-3.61 0
CD (P=0.05)	0.59	0.45	0.33	3.55	SD-0.473

Table 3. Performance of *A. nilotica* seed sources under nursery condition 6 months after sowing.

Seed source (S)	Shoot length (cm)	Root length (cm)	Shoot collar diameter (mm)	Root volume (cc)	Number of branches	Shoot dry weight (g/seedling)	Root dry weight (g/seedling)	Drymatter production (g/seedling)
North eastern zone								
Vellore	82.5	31.0	5.8	4.0	6.5	5.540	2.487	8.027
Tirupattur	83.0	32.4	5.2	5.0	6.5	6.011	3.391	9.402
TIRUVANAMALAI	57.8	23.0	5.0	2.5	3.5	3.309	1.543	4.852
North western zone								
Salem	81.3	21.5	5.2	2.0	6.0	5.091	1.683	6.774
DHARMAPURI	69.5	23.0	5.2	4.0	4.0	3.361	1.706	5.067
Western zone								
Erode	68.1	22.5	5.1	2.5	6.5	3.543	1.603	5.146
Coimbatore	75.5	26.5	5.4	3.5	5.0	3.762	1.495	5.257
ALIYAR	69.0	22.3	4.8	2.5	3.5	5.330	2.504	7.834
Southern zone								
VIRUDHUNAGAR	69.0	23.5	5.3	3.5	3.5	4.329	1.889	6.218
Kovilpatty	72.0	20.8	4.8	4.0	3.5	3.165	1.992	5.157
Madurai	70.0	29.0	4.9	2.5	4.5	3.659	1.826	5.485
Paramakudi	65.5	23.5	4.9	3.5	4.5	3.781	1.883	5.614
Cumbum	64.0	29.5	5.0	3.0	3.0	4.126	2.020	6.146
PERIYAKULAM	70.5	26.0	4.5	2.5	4.5	3.818	2.225	6.043
MEAN	71.3	26.0	5.1	3.2	4.8	4.201	2.014	6.215
SEd	2.38	2.10		0.57	0.80	0.269	0.228	0.497
CD (P=0.05)	5.10	4.51	NS	1.22	1.72	0.577	0.488	1.065

Table 4. Performance of the different seed sources of *A. nilotica* seedlings in the field 16 months after planting

Seed source	Survival (%)	Plant height (cm)	Shoot collar diameter (cm)	Number of branches
Northern zone				
Vellore	91(73)	319.0	5.2	224
Tirupattur	91(73)	327.5	6.0	243
Tiruvanamalai	75(60)	208.5	2.3	107
North western zone				
Salem	87(69)	151.0	2.2	82
Dharmapuri	89(71)	197.0	3.1	115
Western zone				
Erode	79(63)	238.0	4.5	204
Coimbatore	79(63)	286.0	4.1	195
Aliyar	91(73)	239.0	4.6	190
Southern zone				
Virudhunagar	74(60)	279.5	3.9	140
Kovipatty	89(71)	188.5	2.8	90
Madurai	77(61)	308.5	4.6	171
Paramakudi	89(71)	240.5	4.2	121
Cumbum	85(67)	324.0	5.1	205
Periyakulam	57(59)	284.0	3.6	158
Mean	85(67)	256.5	4.0	160
SEd	1.2	4.59	0.08	4.7
CD (P=0.05)	2.6	9.85	0.17	10.2

Relation of *Acacia nilotica* Seed Coat Dormancy with Components of the Species Natural Habitat

Essam I. Warrag[1] and Mashair A. Eltigani[2]
[1]Institute of Environmental Studies, University of Khartoum
[2]Forest National Corporation, Sudan

Abstract

Acacia nilotica (sunt), an important riverain tree species in Sudan, possesses seed coat dormancy (impermeable). The common sulfuric acid treatment is expensive, hazardous and with associated environmental problems. In the field, the untreated seeds germinate, indicating the importance of the natural habitat in breaking the seed coat dormancy. This study attempted to simulate natural conditions to identify the critical factors that lead to breaking of the dormancy. Pods were collected from a typical sunt forest and divided into pods, clean seeds, and unclean seeds. They were soaked in water for periods up to 24 weeks at two sites with or without forest soil. Germination was assessed every 3 weeks. The study confirmed that factors similar to the components found in the natural habitat have a significant effect in breaking the dormancy. The length of soaking period was the most critical factor; germination increased with soaking time and reached the highest value after 18 weeks and then decreased. The 18-week period is close to the average length of the natural flooding period. Water treatment is suggested as an alternative method to treating with sulfuric acid. Cheap tanks of variable sizes can be used for treatment within the forest area. The study highlighted the importance of understanding the ecological relations between the species and its natural environment.

Key words: *Acacia nilotica*, riverain forest, germination, seed coat dormancy.

Introduction

Acacia nilotica (L) Willed, ex Del., (sunt) is a very important multipurpose leguminous tree species in Sudan. The species is widely distributed in subtropical and tropical Africa. It has nine subspecies with distinctive geographical ranges, with seven subspecies occurring in Africa and four in Sudan (El Amin 1990, Vogt 1995). It is the second priority species in Sudan for its products and for its environmental role along the banks of the River Nile and its tributaries. The tree has a variety of uses and products, such as tanning, fuelwood, furniture, boat building and railway sleepers (Badi *et al.* 1989). Other uses include production of ink and various local medicinal products (Vogt 1995).

The subspecies *tomentosa* is a riverain tree that dominates the banks of the Blue Nile and its tributaries (the Dinder and Rahad). It is found mainly in low basins along the banks, commonly called mayaas, that flood during the flooding season of the Blue Nile (Figure 1). Water can stay in the mayaas for up to six months. The subspecies constitutes the main component of riverain forests that have been under proper management for a long time. The best soil lies between the riverbanks and the inundated basin (El Amin 1973). The species can regenerate naturally. Seeds germinate profusely and vigorously as the floodwater subsides.

Artificial regeneration, which is the common method used by the Forest National Corporation, depends on breaking the seed coat dormancy for germination. *A. nilotica* and *A. suberiana* have the thickest seed coat among the Acacias of the Sudan (Abdel Dafai, 1977). Artificial germination cannot occur without treating and loosening of the seed coat (FAO 1985). The commonly used method in Sudan is the concentrated sulfuric acid (95%) treatment. Other treatments used at experimental levels are: use of electrical needles, and rubbing and nicking with sharp tools. Soaking in water for up to 192 hrs was not successful in breaking the dormancy (Mohamed 1981, Bebawi and Mohamed 1985).

Use of sulfuric acid is very common in central Sudan. The treatment is expensive and is hazardous to both people and the environment. Disposal of the acid after its use adds to the environmental problems. The Sudan Forest National Corporation treats about 15 to 20 tons of seeds annually requiring 1.5 to 2 tons of sulfuric acid (10 kg of seeds per liter of acid). The alternative treatments have limitations and are suitable for small quantities only. Accordingly, there is a need for environmentally safe treatments to avoid the acid cost and the problems associated with its use.

The riverain natural habitat of the species, where it germinates and regenerates naturally, suggests a strong relationship between the species and its environment. The major factor found in the riverain areas is the extended soaking of pods and seeds in the mayaa`s conditions. This may indicate that the breaking of the seed coat dormancy is due to the extended soaking of pods and seeds in water or soil factors or other factors in the ecosystem. Also, it was speculated that germination occurs in seeds with damaged seed coats due to infection or other physical factors. Mimicking of the natural environment of the seasonal wet and dry tropics may also involve the frequent fires that occur during the dry season. Fire is a powerful natural factor in breaking the seed coat dormancy of *Tectona grandis* and *Acacia mangium.*

The aim of this study was to investigate the relationship between the seed coat dormancy of *A. nilotica* seeds and the components of the natural habitat. It was designed to test the hypothesis that factors similar to the components of the natural ecosystem will break the seed coat dormancy. The factors tested were length of soaking period of seeds and pods, seed category, shade, and soil.

Materials and Methods

The study was subdivided into areas involving pod collection, initial germination tests, application of treatments, evaluation of germination, and statistical analysis.

Pod collection and handling

Three sacks of *A. nilotica* subspecies *tomentosa* pods (20 kg each) were collected in March 1997 from Elgazair Forest on the Western bank of the Blue Nile. Elgazair is a typical riverain forest that is dominated by *A. nilotica.* The pods were bulked and divided to three designated lots. One lot was used as pods and referred to as pod category. The pods of the other lots were ground, and seeds were extracted. Seeds of the second lot were used directly and referred to as the unclean seeds category while the third lot was cleaned from infected and damaged seeds and referred to as clean seeds category. Seeds were soaked in water for 24 hr and floaters were discarded.. The remaining seeds were dried and checked by eye for infection during the cleaning. The percentage of damaged and infected seeds was 37%. Initial germination tests were carried out for the three categories using the common concentrated sulfuric acid treatment for 30 minutes in three replications. The germination percent after three weeks was 70% for the clean seeds, 48% for the unclean seeds and 46% for the pods.

Experimental details

The treatments were carried out at El Mugran Nursery in Khartoum State while the subsequent germination tests were carried in a controlled germination room. The treatments consist of soaking the three lots in containers of water with or without soil at two sites in the nursery that vary in shade levels. Seed samples were then taken periodically from each container for germination tests.

The containers (40 cm X 30 cm X 30 cm) were arranged in two sites at the nursery, one with low shade (LS) and one with high shade (HS), receiving approximately 70% and 30% sunlight, respectively. At each site, half of the containers were filled up to 10 cm of soil from El Mugran *A. nilotica* forest in Khartoum state while the others were left without soil. Each lot of three categories was divided into 12 parts and placed in the containers at the two sites. The categories were replicated 3 times per site and soil. All the containers were then filled with water, and water was added regularly to keep the containers full for 24 weeks.

Germination tests

Germination tests were performed on samples taken every three weeks from the soaked seeds and pods, representing 9 soaking periods. Two samples of 100 seeds each were randomly taken from each container at day 1 and thereafter 3, 6, 9, 12, 15, 18, 21 and 24 weeks from soaking. The seeds and pods were placed directly in plastic dishes filled with sand soil and irrigated every two days in a germination room with average temperature of 2°C. Germination percentage was recorded after two weeks. Parallel check tests were carried out for untreated seeds from the three categories. Analysis of variance (ANOVA) procedures were run to determine the effect of length of soaking and the effect of seed category, site, and soil at each soaking period on germination using the Statistical Analysis System (SAS). Duncan's Multiple Range test was used to separate between means.

Results

Breaking of *A. nilotica* seed coat dormancy was significantly affected by the treatments. The length of time that seeds stay in water was the most critical factor.

Effect of length of soaking

The average effect of the length of soaking time was highly significant on the germination percentage ($p = 0.0001$). Germination percentage was 0% at day 1 for all the treatments and increased with time and reached its maximum after 18 weeks (Table 1). It then decreased to reach its minimum germination percentage after 24 weeks. This trend was observed with the seed categories, and with soil and site treatments (Table 2, 3 and 4).

Seed categories

The effect of soaking on each seed category was close to the general trend. At each soaking period, the clean seeds had higher germination percentages followed by the unclean seeds and pods (Table 2). The maximum germination percentage occurred after 18 weeks. The pods and unclean seed categories showed similar results.

The site

Similar to the seed categories, the effect of length of soaking for each site followed the general trend. Generally, the high shade site (HS) had higher germination percentages than the low shade site (Table 3).

The soil

Similar to the seed categories and sites, the presence or absence of soil followed the general trend. The maximum germination percentage occurred after 18 weeks of soaking. The effect of the presence of soil at each soaking period was not significant (Table 4).

Discussion

The results confirmed the hypothesis that prolonged immersion in water is directly related to increased breaking of seed dormancy of *A. nilotica*. Also, significant effect of the length of soaking, seed category, and site on breaking of seed dormancy were identified.

Extended soaking in water was the most important factor in breaking the seed dormancy of *A. nilotica*. The comparison between the soaked seeds and untreated (unsoaked) seeds revealed that soaking is necessary for germination (Tables 1, 2, 3, and 4). The untreated seeds always failed to germinate (0% germination). The germination percent of the soaked seeds increased with time, reaching its highest value at 18 and 21 weeks of soaking after which it decreased. The extended soaking of seeds in water could result

in 80% germination percentage (100% was obtained in some replications). This result is comparable to the use of acid for breaking *A. nilotica* seed coat dormancy, with germination percentages up to 85% (Mohamed and Abdel Majed, 1996).

The significantly higher germination percentage of the clean seed category (Tables 3 and 4) rejected the idea that the natural germination was due to damaged and infected seeds. The similarity between the unclean seeds and the pods further showed that the presence of pod tissue did not enhance germination. The germination percentage of the clean seed category reached up to 80% in some replications. The difference between the clean seed category and the unclean seeds and pods was close to the infection percentage.

The significantly higher germination percent of the high shade site was similar to that found in the natural environment, with the presence of shade from big trees and lower evapo-transpiration resulting in germination. The results of the soil treatment showed that the forest soil did not have an effect on breaking seed dormancy. However, from observations, the role of soil in the natural habitat might be in presenting an immediate seed bed after the recession of the floodwater.

The trend of the germination with the length of soaking showed the relationship between the species and its natural riverain habitat. Naturally, seeds could be immersed in water for varying lengths of time according to the seasonal flooding. Abdel Dafai (1977) observed that seed coat becomes thicker as the site inhabited by the species becomes wetter. It seems that strategy of natural regeneration might be that pods and seeds of *A. nilotica* soaked during the flood season would gradually be affected by water until the seed coat becomes permeable to water. The result would be germination at the end of the flooding season, which normally ranges between 4 to more than 6 months (Badi *et al* 1989). Flooding for more than 6 months might destroy the embryonic tissues.

Conclusions

The study confirmed that factors similar to the components of the riverain natural habitat of the species would break the seed coat dormancy of *A. nilotica*. This indicated relationships between the species and the ecosystem. Extended soaking of seed in water had a gradual softening effect on the seed coat until it became permeable to water. Accordingly, germination percentage increased gradually with time until week 18 and then decreased gradually until it reached its minimum level at 24 weeks, probably due to damage to the embryonic tissues. Using clean seeds and treating them with water under shade increased germination percentage. The variation in the germination reflected variation in seed coat. Use of cheap containers at the forest site for cold water treatment can be adopted.

Literature cited

Abdel afai, A.R., 1977. Growth and vegetative propagation of some of the indigenous tree species of the Sudan. M.Sc thesis U of K, Sudan.

Badi, K.A., Ahmed, A. El Houri, and Bayoumi, A.M.S., 1989. The Forest of the Sudan–Agricultural Research Council (NCR), Khartoum.

Bebawi, F.E, and Mohamed, S.M., 1985. The pretreatment of seeds of six Sudanese Acacia to improve their germination response. Faculty of Agriculture, Shumbat, Sudan, Seed Science and Technology, vol. 13, pp. 111-119.

FAO, 1985. A guide to forest seed handling. FAO, Rome.

El Amin, H.M., 1990. Trees and Shrubs of the Sudan. Ithaca press.

El Amin, H.M., 1973. Sudan Acacias, Bulletin No.1. Forest Research Institute, Khartoum, Sudan, pp. 30-33.

Mohamed, S.M., 1981. Ecological studies on germination and establishment of some Sudanese *Acacias*. M.Sc. thesis. University of Khartoum.

Mohamed, S.M., and Abdel Majed, T.D., 1996. *Acacia nilotica* (L.) Willed ex Del. Seed handling and silvicultural operations. National Tree Seed Centre, Soba.

Vogt, K., 1995. Common trees and shrubs of dry land Sudan. A common field guide to the identification of propagation and uses. SOS Sahel International.

Table 1: Average germination percent at the soaking periods.

Length of soaking/week	Mean germination (%)
Day 1	0.0
3 weeks	3.944 E
6 weeks	11.333 D
9 weeks	20.389 C
12 weeks	27.333 B
15 weeks	28.444 B
18 weeks	33.222 A
21 weeks	20.667 C
24 weeks	3.278 E

Means with the same letters are not significantly different.

Table 2. Germination percentage for the seed categories at the soaking periods

Length of soaking	Clean seed (X)	Unclean seed (S)	Pod (F)
Day 1	0.0	0.0	0.0
3 weeks	4.500 E (a)	4.083 E (a)	3.250 D (a)
6 weeks	19.500 D (a)	8.833 D (b)	5.667 D (b)
9 weeks	33.667 BC (a)	17.833 C (b)	9.667 C ©
12 weeks	39.500 B (a)	22.000 CB (b)	20.500 A (b)
15 weeks	41.333 B (a)	24.000 AB (b)	20.000 A (b)
18 weeks	50.833 A (a)	28.333 A (b)	20.500 A ©
21 weeks	29.667 C (a)	18.000 C (b)	14.333 B (b)
24 weeks	2.833 E (a)	3.667 E (a)	3.333 D (a)

Means with the same upper case letters in the same column and with the same lower case letters in the same row are not significantly different.

Table 3. Effect of length of soaking and shade on germination.

Length of soaking	High shade site	Low shade site (p)
Day 1	0.0	0.0
3 weeks	4.278 D (a)	3.611 F (a)
6 weeks	15.222 C (a)	7.444 E (b)
9 weeks	25.222 B (a)	15.556 D (b)
12 weeks	33.222 A (a)	21.444 B (b)
15 weeks	34.333 A (a)	22.556 B (b)
18 weeks	36.889 A (a)	29.556 A (a)
21 weeks	23.333 A (a)	18.000 CD (b)
24 weeks	4.444 D (a)	2.111 F (b)

Means with the same upper case letters in the same column and with the same lower case letters in the same row are not significantly different.

Table 4. Effect of length of soaking and soil on germination.

Length of soaking	No Soil	Forest Soil
Day 1	0.0	0.0
3 weeks	3.611 F (a)	4.278 ED (a)
6 weeks	7.444 E (a)	9.833 D (a)
9 weeks	15.555 D (a)	19.667 C (a)
12 weeks	21.444 BC (a)	27.111 B (a)
15 weeks	22.556 B (a)	27.889 B (a)
18 weeks	29.556 A (b)	37.778 A (a)
21 weeks	18.000 CD (b)	24.111 BC (a)
24 weeks	2.111 F (a)	3.444 E (a)

Means with the same upper case letters in the same column and with the same lower case letters in the same row are not significantly different.

Figure 1. Photo showing the flooding season of the Blue Nile.

SECTION II

ABSTRACTS

Nicaragua Seed Collection Program for Reforestation Activities in Watershed Restoration: USDA Hurricane Mitch Project

Richard Chavez and Sarah Workman
USDA Project Mitch Casa Grande Carretera Sur Km 5.5 Managua, Nicaragua
sworkman@humr.org.ni

Abstract

Deforestation adversely impacts the natural resources, environmental health and the socioeconomic conditions of communities in the geographic region. In Nicaragua, deforestation has caused decline in forestry products output and resulted in watershed destabilization (e.g. damage caused by Hurricane Mitch, October 1998). The USDA Seed Collection Program, working in coordination with the National Tree Seed Center and the National University of Nicaragua-Leon, is designed to collect and provide seed to support reforestation activities for watershed restoration. The program teams up with PVO/NGO and local partner groups in areas affected by Hurricane Mitch. The project also supports the other reforestation efforts in the country. Through this program, from August to November 2000, approximately 405 kg of native forest species seed such as *Platymiscium pleiostachyum* (Coyote), *Guaiacum sanctum* (Guayacán), *Liquidambar styraciflua* (Sweetgum), *Andira inermis* (Almendro de río), and *Caesalpinia velutina* (Mandagual or Aripin) were collected. We anticipate collection of over 3,500 kg of seed of at least 50 different native species in 2001 to support watershed restoration in Nicaragua.

Keywords: seed collection, watershed restoration, biodiversity.

Optimization of Seed Germination and Assessment of Genetic Diversity in *Dalbergia sissoo* Roxb. (Shisham).

P. Dubey, Nikhil Shringirishi, Narendra K. Shukla, Swati Saxena, R.J. Srivastava and B.S. Burfal,

Forest Research Institute, U.P., 18 - G.T. Road, Kanpur. India – 208024, Phone/ Fax - +91-512-541092 (O)

E-mail: silva_south@hotmail.com

Abstract

Dalbergia sissoo Roxb.(Shisham) belongs to sub-family Papilionoidae of the Fabaceae family. It is an important tree for timber, fodder and fuelwood. This study was undertaken to determine seed source variation of this species and to standardize the germination techniques. Seeds were collected from thirteen seed sources. There was significant genetic variation among seed sources for seed morphological traits (seed length, seed width, seed thickness, 100 g seed weight), moisture content and germination percent. Differences in trait means and variances were found to be statistically significant among the populations. In the correlation studies of traits and geographical factors, germination percent displayed a significant positive correlation with latitude. Correlation studies among seed traits revealed that at the phenotypic level seed width showed a posltive correlation with seed length. Moisture content had a negative association with seed thickness. At the genotypic level, the study indicated a positive significant association between seed width and seed length. The 100g seed weight also gave significant positive correlation between seed length and width, while moisture content was significantly negative in its association with seed thickness and 100g seed weight. The heritability in the broad sense was highest for germination percent (94.4) followed by seed thickness. The little difference between genotypic and phenotypic coefficient of variation indicates a negligible influence of the environment in the expression of these characters. Maximum germination for most of the seed sources occurred between the germination paper and at temperature 30^{0}C. Similarly, the maximium germination value was also obtained with this temperature and substrate. The Solan seed source had the highest germination percent and germination value.

Key words: seed source, seed traits, heritability, germination value, GCV, PCV.

IDPI – guided Phytobiopsy

J A Vozzo, PhD; Ramesh Patel, MD;
Durisala Desaiah, PhD; and Asmita Roy, B Sc.,
University of Mississippi Medical Center, Departments of Radiology, Neurology, Jackson, MS; USDA-FS, Starkville, MS

Abstract

The IDPI procedure provides a useful comparison of dormant and germinated seed tissues to correlate form, function, and amount of metabolic substrate during treatments and storage trials. Using computerized tomography (CT) for biodensity of morphology, and magnetic resonance imaging (MRI) of mobile proton distributions for comparative physiology, a slightly invasive procedure allows quantitative chemical analyses. CT uses thin, contiguous, nondestructive slices of single-plane images to identify and quantify an area and volume of any tissue. The data is expressed in either histograms of densities or numerical mapping of the same density units. MRI indicates the presence and distributions of the hydrogen ion density for bulk water and/or fatty acid molecules. The biopsy sample is extracted through a 1.0- to 3.0-mm bore penetrating the seedcoat. Chemical analyses (nitric oxide synthase) are quantitative for elemental and organic changes in the tissue.

Keywords: seed, dormant, germination, computerized tomography (CT), magnetic resonance imaging (MRI).

Seed Maturation Under Artificial Conditions for Immaturely Collected Tree Seeds in Burkina Faso

Kenneth Sahlén [1] and Louis Sawadogo [2]

[1] SLU, Dept of Silviculture, S-90183 Umeå, Sweden; [2]CNRST/INERA, 03 BP 7047 OUAGADOUGOU 03, Burkina Faso

Abstract

Burkina Faso is situated in a semiarid area in West Africa, where seed coat dormancy and insect damage are common problems among tree species. To determine whether it is possible to address these problems, fruits of *Acacia macrostachya, Cassia sieberiana, Piliostigma thonningii, Piliostigma reticulatum and Ziziphus mauretania* were collected weekly for 5 weeks (20/11 1995 to 1/1 1996) in the Tiogo forest. The fruits were subsequently stored at ambient temperature (25°C) and in a refrigerator at +5° to +10°C for 29 weeks. The moisture content at the first collection was greater than 50%. At the last collection, natural seed dispersal had occurred for all species except *P. thonningii*. The moisture content decreased at a slower rate for seeds stored at ambient temperature than in a refrigerator. The germination capacity of *Acacia macrostachya* three weeks after collection (25/12) was higher (73%) after cold storage than after ambient storage (39%). A similar difference was also found for *Cassia sieberiana* with 70% and 0% germination, respectively, after collection 11/12. This difference remained after 29 weeks storage. For *Acacia macrostachya, Piliostigma thonningii* and *Piliostigma reticulatum,* most seeds stored at ambient temperature were insect damaged, whereas almost no insect damages occurred during cold storage.

Keywords: seed collection, immature seeds, moisture content, germination.

Effect of Seed Source and Period of Storage on Enzyme Activity of *Acacia nilotica* (L.) Wild. Subsp. *indica* Benth.

A. Vijayaragavan and K. Vanangamudi
Forest College and Research Institute
Mettupalayam - 641 301,Tamil Nadu, INDIA

Abstract

Acacia nilotica is an important multipurpose tree widely used for fuelwood, fodder, timber, tannin, and gum. The climate of India greatly accelerates seed ageing phenomenon at ambient storage environment causing deterioration and loss of viability. Keeping this in mind, an investigation involving eleven different seed sources of *Acacia nilotica* seeds, collected from four different agroclimatic zones of Tamil Nadu were evaluated to determine the storage potential of the seed. After the initial evaluation, the seeds at 8 % moisture content were packed according to seed source in plastic containers and stored under ambient conditions. The samples were evaluated every three months for enzyme activity, seed germinability and vigour. The results after twenty-one months of storage indicated that Erode and Aliyar sources of the Western zone had higher enzyme activity (amylase, catalase and dehydrogenase), which in turn had higher germination and seedling vigour when compared to other seed sources.

Keywords: deterioration, seed storage, germination, enzyme activity

Effect of Seed Source on Physiological Quality of *Albizia lebbeck* (L.) Benth Seeds in Storage

A. Vijayaragavan and K. Vanangamudi
Forest College and Research Institute, Mettupalayam - 641 301
Tamil Nadu, INDIA

Abstract

Albizia lebbeck commonly called as Vagai or Siris, is a nitrogen fixing, semideciduous tree species, whose leaves and twigs are excellent fodder for camels and other cattle. It is also an excellent source for fuel, charcoal, jaggery mould and gum. Generally, seeds deteriorate during prolonged storage, but the rate of deterioration varies greatly among the species and provenances. Keeping these in mind, an investigation involving eight different seed sources of *A. lebbeck* seeds collected from four different agro-climatic zones of Tamil Nadu, to evaluate the storage potential of this seed was conducted. After initial evaluation, the seeds at 8 % moisture content were packed according to source in plastic containers and stored under ambient conditions. The seed samples were evaluated every three months for seed germinability and vigour. Results, after twenty one months of storage, revealed that Coimbatore and Aliyar sources of the Western zone stored better based on higher germination and seedling vigour, as compared to other seed sources.

Keywords: seed deterioration, storage, germination, seed moisture content.

Cultivation of an Endangered and Valuable Tree Species, *Camellia grijsii*

Yuexia Weng
Research Institute of Subtropical Forestry, The Chinese Academy of Forestry, Fuyang, Zhejiang, 311400 China

Abstract

The oil from *Camellia grijsii* (GRI) seeds can improve human serum lipid condition and delay aging. Further comparative studies of GRI, olive (OLV), *C.oleifera* seed oil (OLF) and olein on human embryo 2BS cell cultures revealed the similar antisenile effects of GRI and OLV. The amount of lipid peroxides (LPO) and the life span of cell cultures given OLV and GRI were greater than that of the OLF. The results agree with later clinical experiments, in which significant improvement of human serum LPO, superoxide dismutase (SOD) and blood viscosity were found among patients who consumed GRI as their sole cooking oil at 50 g/g for 40 days. The obvious benefits of these oils resulted in increased demands for GRI oil in the domestic and foreign markets.

The oil yield from the seeds of wild *C. grijsii* is very low and fruiting occurs once in every 7-8 years. To address this problem, a project was initiated to continuously select superior mother trees. Also, we wanted to develop techniques for grafting scions of wild *C. grijsii* on to adult *C. oleifera* to test the comparative yield of clones and mating compatibility between different clones. We also wanted to establish a core gene bank of *C. grijsii* where variations in the characteristics of economic importance are observed. Based on our results, 5 isolated "pair clones" orchards have been established in the "The Lake of a Thousand Islands" region by using adult grafting techniques. Each orchard produces seeds of one parent - a cultivar and a certain cultivar must be paired with another cultivar to produce another "pair clones" orchard that is compatible for afforestation, thus gaining high yield. In year 2000, all of the orchards have fruited and some of the trees exhibited characteristics associated with superior cultivars. The superior cultivars will be identified in 2001 and planted in suitable area in subtropical regions for demonstration.

Keywords: oil, fruiting, grafting techniques, orchards.