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NORTHERN RAILWAY

Headquarters Office
Baroda House,
New Delhi
Date: 20.06.2013

उत्तर रेलवे प्रधान कार्यालय
प्रेषित
24 JUN 2013
बड़ौदा हाऊस, नई दिल्ली

No. 42-W/69 Land/

**Divisional Railway Manager**
**Northern Railway,**
**NDLS, MB, LKO, UMB & FZR.**

**Subject: Tree Plantation**

Monsoon has already arrived, before time. Divisions must have started tree plantation in a planned manner. As Babul tree is an almost evergreen moderate size tree and essentially a tree of semi-arid and arid areas, it has been decided that efforts would be augmented to plant Babul trees along with Bougainvillea (of different colour flowers) in respect of plantation in identified pockets along Railway track in the ensuing monsoon. These trees and shrubs should be planted beyond 9 metre from railway track up to railway Boundary Post.

In addition, the existing practice to plant Bougainvillea along station platform fencing and at level crossing gates on its either side should be given impetus.

As monsoon has begun, Divisions are to augment the Plantation drive on the above lines, to not only achieve the set target for the year but also to exceed the same, as Babul can also be planted through direct sowing of seed.

Divisions are requested to submit its action plan and fortnightly progress on the plantation of Babul and Bougainvillea.

Some literature on Babul tree, obtained for FRI, Dehradun, is attached. / SM-/44

(P.K. Aggarwal)
C.E./MRTS
For General Manager (Engineering)

Copy to CE/TSP, CE/RC, CE/G & CE/TMS

O/C

Copy to Addl. General Manager for kind information.

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# Nursery and Plantation Technology of *Acacia nilotica*

## 1. Introduction

*Acacia nilotica* is indigenous to western part of the Indo-Gangetic plain and the northern part of the Deccan plateau and found scattered in agricultural fields, village grazing lands, wasteland, ravines, bunds, undulating grounds, along the national highways and railways lines. Mostly it occurs as an isolated tree and rarely found in patches and to a limited extent in forests. Generally, it is absent in areas receiving more than 1250 mm annual rainfall and in localities experiencing intense frost and cold. It is a species of Southern Tropical dry deciduous forests and Southern tropical thorn forests as distinguished by Champion & Seth (1968) and a suitable species for agroforestry. Outside India, it is also found in Myanmar, Sri Lanka, Pakistan, Saudi Arabia, Egypt and tropical Africa, very common in Sudan. It is essentially a tree of semi-arid and arid areas restricted below 450 m elevation. In its natural zone of occurrence, the absolute maximum shade temperature varies from about $40^0$ C to $48^0$ C and the absolute minimum shade temperature from about $1^0$C to $15^0$C. Frost and droughts are common in its zone of occurrence.

*A. nilotica* is an almost evergreen moderate size tree with a short, thick, cylindrical trunk, thin spreading crown and healthy foliage. It grows on a variety of soils but its best growth is found on fresh alluvial soils of riverain areas subject to annual flooding and on black cotton soils. The species is very exacting to its moisture needs and will not grow in soils without an adequate supply of moisture in the soil or sub-soil. It will also not grow in hard soils which obstruct the penetration of roots. It thrives even in saline soils with kankar pan underneath provided the moisture availability is not hindered.

## 2. Survey/Review of Literature

*Acacia nilotica* is a strong light-demander and intolerant of suppression of any kind. It is fairly drought-resistant mainly due to its deep and extensive root system. In some cases, the tap root may reach 8 m deep into the soil in search of water. With increasing age, all roots reach the same size and the root system becomes compact and massive. The growth of the seedlings depends upon the soil type, weed competition, intensity of shade and availability of moisture. The growth is better in porous soil than on

clayey and stiff soils. The seedlings raised on mounds always grow better than raised on flat ground or in pits. Frequent natural regeneration comes up on ploughed land and new embankments, field boundaries etc. Weeds competition seriously affects the plant as the growth is always better in the weeded plots than in the un-weeded plots.

The seedlings are strong light-demander and the growth is adversely affected even by light shade. Similarly, irrigation boosts up the growth considerably but this effect is noticed only in the weeded and un-shaded plots. Controlled grazing to check the heavy rank growth of grass is helpful not only for recycling seed but for healthy growth of seedlings. The effect of moisture is evident on the alluvium favourably situated to receive annual floods where the dense natural regeneration will come up. However, after the receding of water, the drought brings about heavy mortality. Natural regeneration therefore remains an unsolved problem. The growth of seedlings is fairly fast but varies according to the site and climatic conditions. At canal sides of Punjab, seedlings attain 50 cm to 1 meter in one season of growth. The fast rate of growth is maintained further in the sapling and pole stages.

## 3. State of Knowledge – Major Findings and Management Status

*Acacia nilotica* can be easily raised by direct sowings both in rain-fed and irrigated conditions, in combination with agricultural crops and by raising seedlings in the nursery. Direct sowing is by far the cheapest and easiest method. Naked root seedlings are however not successful, as the young root system is very sensitive and needs extreme care. Stump planting is also not successful. Container grown seedlings give high success particularly in dry areas and avenue plantations.

**Nursery Technology**

***Seed Collection and Storage***

Abundant crops of seed are produced almost every year. Drought affects the seed production adversely. About 5-7 year old saplings start producing seed. The ripe pods are blown from the trees by the hot dry winds during May-June and may be collected from the ground under the trees. The pods are semi-dried, tied in coarse cloth and beaten by sticks, winnowed to separate the clean seed. Seeds from about 40 percent of the seed weight of the pods. The pods of *Acacia nilotica* are readily eaten by sheep, goats and cattle and the seeds ejected out through dropping can be collected to separate the seed. In

case of sheep, the seed is ejected through mouth during rumination. The ejected seed germinates easily due to the reaction of fermentation and moistening and therefore considered superior for artificial regeneration.

Seed can be stored in gunny bags or tins in a cool and dry place for its use in the same season. For longer storage, air-tight containers be used. Seed retains viability for many years, no appreciable fall in germination capacity was noticed upto 3 years, however, after eleven years storage it came down to 12% (Dent, 1948).

Seed weight varies considerably among provenances ranging from 6600 to 11600 seeds per kg. Germination capacity from 50 to 90 percent and plant percent from 25 to 75 percent in expected. Germination commences one to three weeks after sowing and is mostly complete in a month though a few seeds may continue to germinate till much later (Anon, 1983). It is reported that big sized seeds impart seedlings vigour and produce quick and uniform germination (Bagchi & Dobriyal, 1990). This vigour is maintained throughout its growth period (Bagchi, 1992).

***Pre-sowing Treatment***

The seed of *Acacia nilotica* exhibits seed dormancy as the testa is very hard. To hasten and to ensure better germination, seed requires pre-sowing treatment. The seed may be immersed in cold water for 48 hrs before sowing or it may be immersed in hot water ($80^0$C) for about 30 minutes and then soaked for 24 hrs. in cold water before sowing. Even prolonged immersion of seed does not reduce germinative capacity and seeds lying for weeks under water in flooded areas germinative when flood recede (Mahendru, 1946). The seed may be first scarified by rubbing on a sand paper and then subjected to boiling water treatment. The scarified seeds may be immersed in boiling water for 10-15 seconds and then allowed to cool and kept in the same water for 18 hrs. The prescription for hot water treatment must be applied meticulously as excessive heating may kill the seeds. Seed is also treated by soaking in concentrated sulphuric acid (90%) for 10-30 minutes and thereafter washing in cold water to remove excessive acid, thus treated seeds can be sown immediately after dying. One a large scale, the seed is fermented in cow-dung or manure heaps for 48 hrs, constantly kept moist until the seeds imbibe well and swell. The seed treated thus is sown immediately in the nursery.

Rhizobium strain No ANM 18 mixed with seeds in slurry and then sown in the polybags gives significant increase in height growth of seedlings (Barua, 1994).

***Nursery Sowings***

The nursery technique for production of field plantable seedlings varies from place to place. In Gujrat, seedlings are raised in containers at nursery stage by sowing the seed in the month of June. After germination, seedlings are allowed to grow in containers to a height of 25-30 cm, when seedlings are shifted enbloc to large containers and maintained be regular weeding and watering until transplanted by next June or the beginning of July on the outbreak of monsoon. In Punjab and Haryana, the seeds are sown in February-March in polybags and planted out in the field during July when the seedlings attain an average height of 30 cm. By doing so, the roots do not grow beyond the size of polypots. Container plants are used generally for rehabilitation of arid plants, scrub forests, for shelterwood belts and wind breaks and for stabilization of sand dunes.

In Karnataka and Rajasthan, the seedlings are raised in trenches by sowing seeds at the commencement of rains. In Maharashtra, raised bunds along contours are used for raising of seedlings and in Uttar Pradesh seeds are sown in ridges (Anon, 1983). Now a days, the seedlings are raised in polybags by sowing seeds in March and planting out in the field after four months in July. One pre-treated seed is sown in each polythene bag of size 5 cm diameter and 22 cm length. One kg. of seed is sufficient to sow about 4000 bags. The depth of sowing is about 1.5 cm. The bags are placed in shallow trough dugout. The bags are regularly watered, but excessive watering is avoided. Germination takes place in a week. The bags are weeded well. Shifting is necessary atleast two weeks before they are to be planted out. The nursery seedlings may be covered with 400 gauge polythene sheet to avoid root striking in the soil.

Adarsh Kumar and Gupta (1990) have suggested an improved nursery technique for production of plantable seedlings in merely 50 days as against 120 or more days as per earlier practices, thus considerably saving the nursery time. In this technique, seed is sown in the third week of May, in lines or drills 2 cm apart at a spacing of 2 cm in a germination box of 80 x 80 x 15 cm containing a mixture of sieved soil, sand and farm yard manure in equal proportion. The germination medium is continuously kept moist and about 1600 seeds are sown in each germination box. Germination takes place in 2-4

days, the sprouted seed may be pricked out and planted 1.0-1.5 cm deep in the polybags of 24 x18 cm size already filled with soil mix of sieved soil, sand and farm yard manure in equal proportion. Pricking is done under shade and watered sufficiently. As the seedlings give rise to young seedlings in the next 3-4 days, they are shifted in direct sunlight. Prophylactic treatment with light spray of 0.2% melathion may be given to the seedlings at the age of 15 days and 35 days. First dose of fertilizer is applied in the soil mix before pricking. It consists of N =0.05 gm/polybag @ 100 kg, and 25 kg N/ha, superphosphate 0.59 gm/polybag @ 100 kg, $P_2O_5$ an muriate of potash ($K_2O$) 0.04 gm per bag @ 25 kg $K_2O$/ha mixed in 30 ml of water placed locally by pouring the same in the 7-10 cm deep planting hole of each polybag. The second dose of fertilizer is applied at the age of 30 days. It consists of urea 0.05 gm/polybag @ 25 kg N/ha and muriate of potash 0.12 gm/polybag @ 75 kg $K_2O$/ha dose and water 30 ml applied with the top dressing of the soil of each seedling. The seedlings by this method attain around 30-35 cm size to become fit for planting in the field. Thus, by sowing seeds in the third week of May, seedlings may be ready for planting out in the field in the first week of July on the onset of rains. It also avoids coiling of roots which is a major cause of failure of plants in the field. The method has been adopted in Haryana, Punjab and Gujrat. Pal & Singh (1990) have further revealed that in areas experiencing drought monsoon especially during the post-planting period due to failure or break of rains, three month old seedlings may perform better than 2 or 4 month old seedlings and exhibit better biological elasticity to adjust their growth.

**Plantation Technology**

Planting is carried out in the pre-dug pits of 30 $cm^3$ in the month of July. Timely planting ensures the success. Missing of monsoon period generally entails heavy mortality. Weeding and grass cutting around the plants is necessary in the first year. Hand watering to the plants in the first season for two times promotes its growth and establishment. Along canal-sides, however, it is not required. In the frosty northern India localities, weak seedlings need protective shade, whereas the healthier seedlings resist frost damage. Irrigation helps to tide over the frost damage. Young seedlings need protection against browsing.

***Direct sowing***

Because of long tap root development, direct sowing is better for raising *A. nilotica* plantations. Direct sowing may be done by broadcast, dibbling; mound sowing, patch sowing, strip sowing, trench sowing, ridge sowing etc. depending upon the area to be sown. Generally, *A. nilotica* is grown on wastelands comprising of village pasture lands, abandoned fields, ravine lands, riveraine beds, strips along railway lines and saline soils. It is one of the principal species recommended for afforestation of wastelands in the arid areas.

*Broadcast sowing*: Broadcast sowing of pre-treated seed or seed processed through alimentary canal of sheep and goats on ploughed land generally gives very good results. Debris of weeds and grasses may be burnt. Sowing alter pre-monsoon showers is generally more advantageous. After sowing, the land should be rolled to cover the seed. Broadcast sowing is advocated for riverain areas which are flooded frequently.

*Ridge and Mound sowing*: In areas subject to floods or in swampy and water-logged situations, sowings on bunds, mounds and ridges are successful. Alignment is done in a manner to allow proper drainage. Ridges about 25 cm high and 5 m apart are prepared before the onset on monsoon. The height of mounds depends mainly on the depth of water in the rainy season. Mounds as high as 60 cm are also prepared along the railway strips where soil has been taken out. In Punjab and Haryana, sowing on flood-drain embankments has given good results. Here, hoeing is done in worked up patches or in the trenches 30 cm x 1 m x 20 cm.

*Patch sowing*: Sowing is generally done in patches or half filled pits for afforestation of wastelands on flat land. Patches of the size of 30 $cm^3$ are dug up in March-April at a spacing of 3m x 3m. For sowing in pits, pits of 60 $cm^3$ may be dug up in the winter months, allowed to weather in the summer months and half-filled to give a slope on the onset of rains. About 10-12 seeds are sown per patch or pit. The germination of the treated seeds starts in about a week and is complete in about two weeks. The germination percent may be about 80 to 90 and average plant percent about 60 to 70. Patch sowings are also adopted for filling up blanks in young babul plantations. Sowing may also be carried out in strips 3m of apart and about 60-75 cm wide in ploughed up lines. Among the post sowing operations, weeding and thinning of the seedlings and their protection against animals are important aspects. Systematic weeding of the young crop

for the first two or three years is essential. Thinning out of seedlings is necessary to reduce competition which may seriously retard their growth.

*Trench sowing*: In ravines and undulating hills, the availability of moisture is the most critical factor deciding the success of plantations. In these areas, trenches are dug to catch and conserve water. The depth of the trench and the type of filling affect the successful establishment of the seedlings (Prajapati *et al*, 1968). Trenches 60 cm deep have been found to be better than the 45 or 75 cm deep. The double trench system impounds the maximum quantity of water. Adoption of 1.8m long, 60 cm deep trenches with the double trench system of refilling is recommended (Prajapati *et al*, 1968). Trenches should be made in advance before the onset of rains. They are spaced about 2 m on the contour and 5 m across the contour. Seeds are sown in a single row or in two rows. Time of sowing is very important as little delay in the dry areas causes heavy failure. Prolonged drought may cause complete failure of sowings.

*Agro-Silviculture method*: Sowing of babul has been done in conjunction with agricultural crops successfully. The area is leased out for 5-7 years. In the first and second year cultivation of field crops in allowed and in the third year a mixture of babul and neem (*Azadirachta indica*) seeds are sown in lines at a minimum distance of 4.5 to 5.5 m along with field crops. The field crops raised are cotton, sesamum, and arhar (Cajanus cajan). Jowar is not allowed after two years, as the seedlings do not get sufficient light for growth. Two years cultivation prior to sowings is found to be necessary for proper aeration of the ground and for elimination of the fungus from the soil. Thinning out of seedlings significantly reduces nortality and increases height and collar diameter growth of the seedlings (Kaul & Gyan Chand, 1966). Pruning of side branches is also carried out. Agri-silviculture mehod promotes vigorous growth because of thorough working of soil, timely weeding and thinning of seedlings. A height of 1-2 to 2-4 meters is attained in two years on deep moist soil and in three years on drier and poor ground.

*Ravine Lands:* In the badly eroded and ravine land one or two continuous trenches 3 to 5 m apart depending upon the slope are made on the periphery of the nalas or gullies. A break of about 30 cm at intervals of 3 m is given. In rest of the area, staggered contour trenches of 1.5 to 6 m 60 cm x 45 cm at spacing of 3.6 m to 4.5 m in lines are dug. The

earth is taken out and heaped on the downhill side of the trench. The spacing along the slope varies from 3 m to 4.5 m. every fifth row is a continuous trench provided with 30 cm to 60 cm wide septa at interval of 3 m. In the gully beds continuous trenches of 60 cm x 45 cm cross section provided with 30 cm septa at every 3m and 60 to 70 cm wide escapes on alternate sides are dug from one bank to the other at 4.5 m intervals.

*Saline and Alkaline Soils:* In mild usar land intermittent or continuous trenches 6 m long, 30 cm wide and 45 cm deep are made spaced about 4.5 to 6 m apart. The lower part of the trenches is filled with earth. The lines for sowings are raised 30 to 45 cm above ground level to check alkaline or saline water from inundating sowing in pits 60 cm in diameter and 120 cm deep filled with imported non-usar soil have given satisfactory results. On saline soils, babul grows better than sissoo and its failure is mainly due to dryness and toxicity; with adequate supply of water, saline lands can be successfully afforested with babul. An outstanding example of afforestation of ravine lands with *Acacia nilotaica* is Fisher forest in Etawah (U.P) which was sown on the bunds as well as side of ravines. The plantations came up well but after about 10 years, it started dying because the tap root could not penetrate the kankar pan underneath and the supply of moisture was limited.

Babul was the main afforestation species in the pre-era of introduction of Eucalyptus hybrid in the northern western states. Now also, it is one of the most widely planted species in the states of Punjab, Harayana, Uttar Pradesh, Rajasthan, Gujrat, Maharashtra and Andhra Pradesh. It is also a good species for social forestry plantations in the agricultural field boundaries as it has thin shade and does not affect the crops adversely for a period of 4 to 5 years. The species is suitable for planting in swampy areas liable to inundation and water-logging, as its roots can resist oxygen deficiency for about 110 days.

## 4. Technologies Available for Dissemination

- ✓ Seed treatment for higher seed germination
- ✓ Nursery Technology
- ✓ Plantation Technology

## 5. Identification of Research and Development Gapes

- Screening of natural variation based on wood quality parameters, fodder and fuel wood.

## 6. Road Map for Future Research

- Selection of plus trees on the basis of wood quality parameters, fodder and fuel wood.
- Development and release of clones with better wood quality, fodder and fuel wood.

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# Nursery and Plantation Technology of Australian Babul
## *(Acacia auriculiformis)*

## 1. Introduction

*Acacia auriculiformis* (Synonyms: *Acacia auriculaeformis* A. Cunn. ex Benth and *Racosperma auriculiformae* (A. Cunn. ex Benth.) Pedley).belongs to family Fabaceae (Mimosoideae) The vernacular names are Northern black wattle (Australian trade name); Coast wattle, Ear pod wattle (English). In India it is commonly known as Australian babul, Kasia, Akashmoni and Sonajhuri (Hindi) (Joker, 2000).

*A. auriculiformis* is endemic to Australia, Papua New Guinea and Indonesia, having a disjunct distribution in three main areas: the lowlands of southern half of the island of New Guinea (Papua New Guinea and Irian Jaya, Indonesia); the lowlands of tropical Northern Territory, Australia; and the Cape York Peninsula of northern Queensland, Australia. It has been widely introduced to many tropical countries in South and Southeast Asia, Africa and Latin America.

*A. auriculiformis* occurs from near sea level to 400 m, but is most common at elevation less than 80 m. It is predominantly found in the seasonally dry tropical lowlands in the humid and subhumid zones. The mean annual rainfall in its natural range varies from 700-2000 mm with a dry season (i.e. monthly rainfall less than 40 mm) may be of 7 months. The mean maximum temperature of the hottest month is 32-34° C and the mean minimum of the coolest month is 17-22° C.

The species is commonly riparian, i.e. ringing perennial rivers and semi-perennial creeks, and tends to form discontinuous populations along drainage systems. It is found most commonly on clay soils; however it exhibits the ability to grow in a variety of soils including calcareous sands and black cracking clays. It can also tolerate highly alkaline and saline soils. Seedlings have the ability to compete with *Imperata cylindrica* during early growth phases and once mature may reduce the grass to a sparse ground cover (Pinyopusarerk, 1996).

## 2. Survey/Review of Literature

*A. auriculiformis* was introduced to India during 1946 and has since become popular as a social forestry species because it tolerates long dry spells and alkaline soils

(Kushalappa and Turnbull, 1991). It has also been introduced to many tropical countries in South and South-East Asia, Africa and Latin America owing to its rapid early growth, ability to fix nitrogen, tolerance of infertile, acidic, alkaline, and saline or seasonally waterlogged soils. Tolerance of moderate dry seasons also makes it very useful species for rehabilitation of degraded lands (Marcar *et al.*, 1991; Pinyopesererk *et al.*, 1991). It is one of the most promising tree species for plantation forestry and reforestation of tropical environments in most parts of India (Kumar *et al.*, 1987). The early introductions of *A. auriculiformis* in India resulted in a landrace of poor form and vigour (Bulgannawar and Math, 1991). Propensity of the species to produce multiple and crooked stems reduced its utility (Hossain *et al.*, 1998). Provenance trials of *A. auriculiformis* were initiated in different environmental regions in India and also in other countries (Luangviriyasaeng *et al*, 1991; Hossain *et al.*, 1998; Nor-Aini *et al.*, 1994; Manaturagimath *et al.*, 1991, Indira, 1999) to select superior provenances possessing single stems and good clearboles. The provenances from Papua New Guinea and Queensland reported to be generally superior when introduced as exotics (Matheson and Harwood, 1997).

Harwood *et al.* (1991) reported occurrence of a small number of individuals with clear straight stems in *A. auriculiformis* provenance trials which were later thinned for converting into seed orchard. These trees were used as candidates for further genetic improvement programmes. Second generation seed orchards of *A. auriculiformis* were reported to be raised in Thailand from open-pollinated seeds of selected families from a first-generation progeny trial/seedling seed orchards (Luangviriyasaeng and Pinyopusarerk, 2002). More than 100 families of candidate plus trees selected in different provenance trials/seed orchards were evaluated. All families from the first-generation seedling seed orchard grew significantly faster than local unimproved seed trees. Most families produced single-stemmed trees with good stem axis persistence and a low frequency of upright branches on the lower part of the stem, indicating a considerable improvement in the stem form over the first generation. Estimates of individual-tree, narrow-sense heritabilities for most growth and form parameters were low, but statistically significant, ranging from 0.06 for repeated forking to 0.20 for stem straightness. Heritability was not significant for presence of upright branches. At Institute of Forest Genetics and Tree Breeding, Coimbatore a systematic breeding

programme has been taken up for *A. auriculiformis* since 1996. First generation seed orchards have been established with introduction from native countries. Second generation seed orchards are also being established through individual selection for stem form and biomass production.

## 3. State of Knowledge – Major Findings and Management Status

### Nursery Technology

The species is generally propagated by seeds as vegetative propagation of mature tree is reported to be difficult as rooting percentage of branch cuttings are is very low. However, vegetative propagation through juvenile cuttings has been developed and are now a routine and simple operation.

***Seed Collection and Storage***

Seed collection is done from the tree or from the ground. If collection is too early, it can be difficult to open the pods while late collection may result in loss of seeds. The seed ripens in January to March and the best time of pod collection is February/March. Generally, small branches with pods are collected in gunny bags and seeds are separated after drying by beating with sticks. After extraction, the funicle can be removed manually by rubbing the seed over a sieve. Seeds are orthodox and can be stored for several years in closed plastic bags. Moisture content for storage should be about 7%. Seeds picked at physiological maturity do not show dormancy, but mature seeds require a pre-germination treatment, such as immersion in boiling water for 1-2 minutes followed by soaking in cold water overnight or soaking in warm water for 24 hours; 40-80% germination occurs between 6-15 days of sowing (Doran and Turnbull, 1997).

Seeds stored in air-tight tins or earthen pots in a cool dry place retain viability nearly for two years. Seeds stored in open are liable to attack by ants.

***Nursery Sowings***

The seeds can be sown in nursery beds or directly in containers in months of Feb/March each year. Germination beds are prepared by well decomposed manure, red earth and burnt ash. Newly emerged seedlings need shade of 50%. Once they are established, 70% full sunlight is optimal. Inoculation with appropriate rhizobia may be beneficial, especially when seedlings are raised in sterilized soil.

### Plantation Technology

The nursery raised seedlings of current season are planted in pits with ball of earth during full monsoon. In general, 3-4 months are needed to raise seedlings to a plantable size of 25 cm in height. The optimal planting density is not clearly established. Most current plantings are spaced at 2- 4 x 2- 4 m, the closer spacing being more suitable for firewood and pulp plantations. Removal of lower branches of young plants has been suggested for improving stem form and of reducing the incidence of multiple stems.

Direct sowing of seed in hoed-up lines is also successful but dry spell after germination takes heavy toll of seedlings necessitating re-sowings.

Under favourable conditions, trees may reach a height of 15 m in 5 years and produce an annual wood increment of 15-20 cubic m/ha over 10-12 years. (ICRAF, 2000). Recommended rotation is 4-5 years for fuel-wood, 8-10 years for pulp and 12-15 years for timber. One or two thinning is required with longer rotations depending on initial spacing, site quality and tree growth.

## 4. Technologies Available for Dissemination

- ✓ Seed, nursery and plantation Technology
- ✓ *Acacia auriculiformis* + Napier grass based silvi-pasture system has been developed for farmers semi-arid regions.

## 5. Identification of Research and Development Gapes

- ➢ Training for the staff involved in seed collection, nursery and plantations should be regular feature.
- ➢ State Forest Department may also invite research expertise for suggestions in their production nurseries.
- ➢ Forestry research updates related to practical/applied aspects in the state should be compiled on yearly basis in a user friendly language and be circulated up to the lowest concerned.

## 6. Road Map for Future Research

This species has strong tendencies to produce more side branches which lower stem productivity and it is undesirable trait for agroforestry systems. Hence, there is need to develop clones having straight stem form with greater clean bole length.

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# Nursery and Plantation Technology of *Acacia senegal*

## 1. Introduction

*Acacia senegal* commonly known as "hashab" is a widespread leguminous tree, found in Sudano-Sahelian zone of Africa from Sudan to Senegal (Raddad, 2006). Its contribution towards environmental protection and economic development in the Sudano-Sahelian region is highly significant. It produces gum Arabic, which is used in a wide variety of products including candy, medicine, cosmetics and as an emulsifier in preventing precipitation of solids in soft drinks (Macrae and Merlin, 2002; Elfadl *et al.* 2000).

Sudan is known to have a higher density of *A. Senegal* with a uniform distribution of the tree in pure stands spread over fast geographic area places the country as the major producer of gum Arabic in the world (Beshai,1984). In Sudan gum Arabic grows in a broad band known as the "Gum belt" lies within the arid and semi-arid zone characterized by an erratic and scanty rainfall, in this zone the hashab tree is of vital importance to the permanent farming systems and gum Arabic production. The species is routinely propagated through seeds, however as *Acacias* are out breeders, there is a high degree of genetic variations (Quoirin, 2003). Moreover, gum Arabic yield per tree varies from 0 to 1 kg per year (Sène, 1989); therefore, there is a great need for reproduction of individuals selected in nature for their abilities to produce large quantities of biomass and gum Arabic.

In India the tree is distributed and indigenous to arid zone of the country e.g. South-east Punjab, parts of Gujarat (Saurashtra, Kutch), mainly in the dary and rocky hills of Aravallis and the sandy tracts of the west of the Aravallis. It is also indigenous of Sind (Pakisthan), Arabia and tropical and sub tropical Africa.

## 2. Survey/Review of Literature

It can survive in area with absolute maximum shade temperature up to 48.3$^0$C and absolute minimum temperature far below freezing point -2.5 to – 5$^0$C. The tree can grow the annual rainfall is as low as 600 mm with 8-11 dry months. The tree occurs on the poorest soil on rocky hills and sandy tracts. It found in Aravalli range (Shallow, stony poor and unstable soil). The tree is suited to sandstone, rocky, gravelly refractory sites,

shifting sand dunes, rocky out-crops, lower and upper pre-dominant, mineral soils and similar sites. It is naturally growing in sand, except in water logged areas.

The tree is a strong light-demander. It is a drought-resistant which can survive extremes of temperature and very poor soil and sand dunes of west Rajasthan. Shoots that failed to develop roots were subjected to micro grafting on rootstocks of *in vitro* germinated seedlings. The rate of successfully grafted shoots was influenced by both scion size and rootstock age. Scion of 2.5-3 cm length gave the best results with 93% successful grafts, whereas only 73% successful grafts were obtained for the scion of 1.5-2 cm length. For the rootstock age, the 14-days-age was found to be more efficient than 7-days-age. That, all (100%) of rootstock aged 14 days grafted successfully while only 83% successful grafts were obtained for the rootstock of 7 days old. Similar observations were reported for sandalwood (Sanjaya *et al.* 2006). Removal of the cotyledons from the rootstock helped in insertion of scion and did not affect graft survival. Although grafting was proved to be simple and easy to use, but relatively higher percentage of failed grafts (27%) was occurred with the young rootstock (7 days-old) and small scion (1.5-2.0 cm). This result is inconsistent with that obtained by Nelson (2006), who reported that the failure in grafting *Acacia koa* was due to the narrow stem diameter of rootstock and young stem tissue of scion which easy damaged. The result showed that, shoot necrosis was observed with both scion length as 7% at (2.5-3 cm) and 27% at (1.5-2 cm), while in rootstock aged 7 days was (14%). According to Sha *et al.* (1985) apical necrosis in shoots may be related to a mineral nutrients deficiency, e.g., Ca, resulting from the high levels of humidity in the container microenvironment. This experiment demonstrated that micro grafting is fast, effective and reliable and could be applied as an alternative to obtain healthy root system for the development of *A. Senegal* plants *in vitro* (Figure 1F). Successful cleft-grafting have been reported for *Acacia mangium* (Monteuuis, 1996) *A.tortilis* (Detrez, 1994), *Faidherbia albida* (Danthu, 2002). Micro grafting of *A. Senegal* shoots overcomes many rooting problems and is independent of growth regulator treatment applied to the regenerated shoots. Moreover, micro grafting of shoots results in both significant reduction in the regeneration period and a significant increase in the production of *A. Senegal* regenerates. The propagated plantlets grew well and did not show morphological abnormalities. The *in vitro* shoot regeneration procedure reported in

this study is rapid, efficient and reproducible thus can be used for large scale reforestation and is expected to contribute to the future genetic manipulation studies of this important multipurpose tree legume.

## 3. State of Knowledge – Major Findings and Management Status

The trees can be raised by direct sowing by planting out entire seedlings preferably in containers, planting bricks etc.

**Nursery Technology**

***Seed Collection and Storage***

Ripe pods are collected from the standing trees. On an average 100 dry pods weigh 89.4 gm yield 43 gm of seeds. Pods with bronze colour ensure minimum germination. Under ordinary conditions seed can be stored for 2 years.

*Pretreatment:* Soaking seed in water at room temperature for 24 – 48 hour is helpful for easy germination. Acid scarification for 20-30 min in concentrated sulphuric acid is also helpful in enhancing germination. Germination commences four days after sowing and is completed within two-three months. 56% germination has been reported.

***Nursery Sowing***

Pre-treated seeds are sown in polythene bags filled with a mixture of good loamy soil and farm yard manure in ratio of 2:1 during June-July. One year old seed lings are planted out in the Monsoon.

**Plantation Technology**

One year old seedling are usually planted in 30 $cm^3$ pits which are half filled with weathered soil and half made to reap on the loner side. Deep planting is beneficial on deep sandy soils. Planting in the first half of July has advantage of favorable temperature during monsoon than the later plantings.

The trees can be raised by direct sowing by planting out entire seedlings preferably in containers, planting bricks etc

## 4. Technologies Available for Dissemination

- ✓ Seed treatment for higher seed germination
- ✓ Nursery Technology
- ✓ Plantation Technology

## 5. Identification of Research and Development Gapes

- Screening of natural variation based on wood quality parameters and gum yield.

## 6. Road Map for Future Research

- Selection of plus trees on the basis of wood quality parameters and gum yield.
- Multilocational trials in each state for identification of site specific clones/families.
- Development and release of clones with faster growth, better wood quality and gum yield.

## Suggested Literature

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