

## PLANTING STOCK IMPROVEMENT DEVELOPMENT OF SEEDLING SEED ORCHARDS

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### **Introduction:**

Tree improvement activities in India were catalysed during the visit of Dr. J. D. Mathew to India in 1962, emphasis was placed on a long term breeding programme for teak with the object to produce superior varieties or cultivars suitable for growth on the moist, semi-moist and dry sites (Kedharnath and Mathew 1962). Later in the year 1977, a project on Tree Improvement and Seed Procurement was started in collaboration with DANIDA, which provided much needed field orientation to the tree improvement activities in India.

In genetical improvement of tree species major emphasis is placed on selection breeding. Some points are generally considered while choosing traits for selection purposes are as follows:

- Sufficient genetic variation for the character should be available,
- The character should be heritable and its heritability should have been worked out,
- Trials have been conducted to screen out geographic variation available in that species.

### **Seed Orchard:**

A seed orchard is a plantation of selected clones or progenies which is isolated or managed to avoid or reduce pollination from outside sources, and managed to produce frequent, abundant and easily harvested crops of seed (OECD 1974).

The concept of seed orchard started with the use of quality seeds as suggested by F.A.L Burgsdorf of Germany in 1787, using specific plantations raised through vegetative propagation in forest tree breeding. N. Sylven suggested establishment of seed orchards converted from seedlings of known seed origin in 1918. In 1931, J. Scrymgeour Wedderburn established first forest tree seed orchard in Scotland. This method of tree improvement was taken up by most of the western countries, and later on by all over the world for the production of quality seeds.

It is long-term quality seed production programme but and expected genetic gain from such orchards are from 30 to 40 percent. Seed orchards are of two types:

1. Seedling seed orchard
2. Clonal seed orchard

**Seedling seed orchard-** Seedling seed orchards are raised from the seeds collected from superior phenotypes. The seedlings planted from this material are roughed to remove inferior trees, leaving the best trees of the best families for seed production.

**Clonal seed orchard-** A seed orchard composed of vegetative propagated trees established primarily from the clonal material of superior phenotype for the production of seed of proven genetic quality.

## Seedling seed orchard

Though in general the quality seed production in forest trees is limited to clonal seed orchards, but the suggestion given by N. Sylven in 1918 regarding conversion of seedlings of known seed origin into seedling seed orchard has laid down the foundation of seedling seed orchard. When compared to clonal seed orchard these orchards require a bigger large area, more number of trees for block planting as families, and it takes longer duration for seed production. During early 60's lot of discussion has taken place about the type of seed orchard to be used (Toda, 1964). It is the decision of individual organisation to decide which type of seed orchard suits to their requirement. Some pros and cons of these seed orchards have been well described by Barber and Dorman (1964).

To solve these problems many designs have been workout to take advantage of seedling seed orchard concept. Some of the important once are by Cameron and Kube (1980), Klein (1974) and Riemenschneider (1977).

### Species Description:

**Acacias** belong to family mimosaceae. There are more than 1200 species of Acacia Wild (Simmons, 1981). The genus occurs naturally in all continents except Europe and Antarctica. There are 729 species currently recognised in Australia and an estimated 120 taxa is yet not described (Maslin, 1981). There are about 115 species in Africa (Ross, 1973). The remainder occurs in Asia.

*Acacia nilotica* (linn), Wild ex Del is known as Babul, Kikar, Babur (Hindi); babla (Bengali); barmura, bawal (Gujarati); jali gobli, gohar (Kannada); babul vedi, babul, babli (Marathi); Kikkar (Punjabi); kuruval (Tamil) and tumma (Telgu).

*Acacia nilotica* is generally accepted as a single natural species. This species is variable in nature. Presently it is recognised into 9 sub species with more or less distinctive morphological ecological and geographical features. In India, *Acacia nilotica* sub sp. *indica*, *A. nilotica* sub sp. *adstringens*, *A. nilotica* sub sp. *cupressiformis* and *A. nilotica* sub sp. *sublata* are reported. The work reported here is on *A. nilotica* sub sp. *indica*.

*Acacia nilotica* sub sp. *indica* is widely distributed in India, particularly in Punjab, Harayana, Uttar Pradesh, M.P., Tamilnadu, Andra Pradesh, Maharastra, Rajasthan and Bihar. It grows naturally in most parts of arid and semi-arid regions. The tree has a very clear bole some times up to 4-6m. It is almost evergreen tree with short, thick and cylindrical trunk. The bark is dark brown to blackish in colour, longitudinally fissured or deeply cracked. The leaves are bi-pinnate with spinescent stipules, pinnules narrowly, oblong, flowers golden yellow globose heads.

Babul is the most useful tree since its origin. It is a very strong and tough timber and nearly twice as hard as teak. Its wood is good for carts, agricultural implements, Charcoal, construction purposes, pulp and paper making. The bark is used for tanning in leather industries. Babul gum is used for various purposes and leaves are good foddors for sheep, goats and camels. Animals also eat the pods. The thorny branches are also used as a fencing material.

***Dalbergia sissoo*** is an important timber-yielding tree of India. It is a deciduous tree and is found in India in deciduous forests or in mixed deciduous forests. It is mostly confined to alluvial soil. Under favourable conditions it is known to attain a height of 30 m with a girth up to 2.4 m. *D. sissoo* is widely used in urban and road side planting of the Indian subcontinent.

In India, the main regions of its occurrence are sub-Himalayan tracts from the Indus to Assam and in Himalayan valleys up to an elevation of 900m and sometimes up to 1500m. It is fast growing, adaptive in its requirements of soil and moisture and can withstand frost to a considerable extent. It prefers porous soil with adequate moisture and therefore, thrives in the alluvial sand or gravel along the banks of rivers. Natural forests of sissoo are common in a sub-Himalayan region from west to east either pure or in mixture with other species like *Shorea robusta*, *Acacia catechu*, *Terminalia tomentosa* etc.

*D. sissoo* is one of the most important tree species in India. The heartwood is brown, very hard, strong and durable and thus it yields one of the most valued furniture, cartwheel and building material. Its heartwood yields about 5% of light brown, non-drying, highly viscous fixed oil, which on cooling becomes semi-solid like Vaseline; this is a suitable lubricant for heavy machinery. It is a multipurpose tree but mainly used as timber tree.

*Dalbergia sissoo* produces, small, pale-yellow flowers. The calyx is downy in nature with short teeth. Corolla yellowish, twice the length of calyx; standard with long claw petal and round limbs. Stamens 9 in a bundle, and ovary is pubescent. Pods are thin and strap shaped, pale brown, glabrous and ripen in November. Detailed information is not available on pollination biology with reference to the mechanism of pollination and mating system. *D. sissoo* has papilionaceous and hermaphrodite flowers and both self and cross-pollination is common in it. The floral biology and the fact that isolated trees produce fertile seeds suggest that there is no barrier to self-fertilisation.

***Eucalyptus camaldulensis***, a member of the Myrtaceae family, was named in the honour of the count of Camadoli who had grown the tree successfully in his garden near Naples in Italy since 1882. In its native land Australia, the species is mostly planted along watercourses. It is characteristic for arid and semi-arid, but also extends into the wetter tropics. In southern Australia, its common name is red gum or river red gum while in central and northern Australia it is known as ghost gum (FAO, 1985). The species is adapted to a wide variety of soils. It produces deciduous bark, peeling off in rather broad plates. It is moderately frost resistant and some times a mature tree can resist temperatures up to -8<sup>0</sup> C (FAO, 1979).

The wood is hard, strong, durable and used for pole, furniture, purloin doors and window frames. It is also used for manufacturing packing cases, battens or beams in rural hose constructions. Eucalyptus is used for pulp, paper, resins, plywood making, chemical industries, fuel, tannin and perfumery.

*Eucalyptus camaldulensis* is naturally regenerated by seed. Flowers are bisexual with fertile male and female organs found in the same flower. Pollination is generally depending on insect or animal vector. In spite of the fact that most species are to some degree self compatible, eucalypts seem to be predominantly out-breeding. Out-breeding is favoured by mechanisms operating at two different developmental stages, reducing the degrees of self-pollination and self-fertilization. Self-pollination within one flower is diminished by protandry of the flowers. Whereas most of the pollen is shed within hours of the shedding of the

operculum, the stigma generally does not become fully receptive until four to seven days later. As the stigma is not sticky and therefore, does not retain pollen well during the first few days after the opening of the flower. The pollen starts losing its viability after three to four days; the probability of intra-floral selfing is small. As, however, all the flowers in the same flower cluster and in clusters in different parts of the crown do not open simultaneously, a considerable amount of self pollination is known to occur within one tree in spite of protandry. Self-fertilization is also reduced by the fact that pollen tubes of foreign pollen grow faster on the stigma and therefore have better chance of fertilizing the ovule. It is also likely that there are gene- controlled incompatibility systems which operate at the embryo stage; these would account for the poor seed set observed in inbred trees.

### **Establishment of Seedling Seed Orchards under FREEP**

**Selection of plus trees:** Selection of phenotypic superior trees is the first and most important step of any tree improvement programme. The trees selected constitute base material for further selection and crossing programmes. These trees are used in establishing first generation seed orchards. They are the products of rare genetic combinations. Different species have by nature different growth and form. Phenotypically selected individuals are generally used for (i) the collection of open pollinated seed for the establishment of plantations; (ii) the collection of open-or control-pollinated seed for progeny trials, though which genetic parameters such as heritability, combining ability and genetic correlations are determined; (iii) the collection of scions for grafts or cuttings. These can be used for progeny or clonal trials, for the establishment of the seed orchards for the production of genetically superior seed or for clone banks although selection trait may vary between different species and programmes. Grading system is developed to select candidate plus tree on the basis of growth and form. The trait under consideration should be under genetic control and it must have considerable economic value. For the selection of CPTs of target species, following traits needs special attention.

- a). Fast growth
- b). Straight clear bole form
- c). Compact crown
- d). High wood density

Wood quality is handled separately. No points as such are proposed for it. Selected tree can be compared with the check trees growing under the same environmental conditions. 50 candidate plus trees of *D. sissoo*, 50 CPTs of *A. nilotica* and 30 CPTs of *E. camaldulensis* have been identified in Rajasthan State for the collection of seeds to raise seedlings for seedling seed orchards (Tables 3-5).

Plus trees are individual trees of out standing merit, initially selected on the basis of superior phenotypic characters like height, diameter, clear bole, etc. Criteria for the selection of plus trees for timber production and scoring performa are given below.

- |              |    |  |
|--------------|----|--|
| 1. Age       | i) | more than half of the rotation age   |
| 2. Growth    | i) | vigorous, healthy and showing superiority in height and diameter when compared with the crop |
| 3. Stem form | i) | Straight stem  |

- ii) Stem cylindrical, circular in cross section, without excessive taper
  - iii) Absence of spiral grain and if present not to exceed five degrees
  - iv) Free from pronounced buttress and fluting
4. Crown and branching
- i) narrow to intermediate in width not suppressed either from the top or from the sides any time
  - ii) light and spreading branches which are either flat or moderately ascending.
  - iii) good natural pruning, none or few epicormic branches
  - iv) dense mass of healthy foliage

5. Free from insect and disease attack.

6. Moderate to good flowering and fruiting.

Tree improvement involves all practices designed to produce genetically more desirable trees and the plus tree selection is only the first step in a series of stages in the breeding and propagation programme.

The ideal tree in a tree improvement/breeding programme is the straightest, fastest growing and most resistant to diseases and pests. Such trees do not exist. There is no tree, which simultaneously performs best in respect of all these attributes. The best tree always represents a compromise. It performs better than other trees when all the criteria together are considered, though it may be out performed in any one of the criteria.

The selection methods in forestry are all faced with the general problem in forestry, the long generation turnover. There can only be one selection in each generation. The two main problems for selection are that the ideal tree does not exist, and that some of the traits are negatively correlated. Even if traits are not negatively correlated it may be difficult to find a tree which is very good on the positive side without having any negative traits.

The first step in the plus tree selection is to state the selection criteria. Once the selection criteria have been clarified, the next procedure is to choose a proper system of selecting. The selection is usually based on a set of criteria rather than one single criterion. This confirms that "ideal" tree represents compromise, which meets several criteria simultaneously in some optimal way. The selection of a candidate plus tree (CPT) for a job needs to specify a set of selection criteria which can in turn, be used to evaluate the suitability of CPT. The selection procedure will be arbitrary if this is not done.

The decision analysis is the most widely accepted method for dealing with a multi-objective decision problem (Keeny, 1982). The rationale for using this method is based on the requirement that all relevant criteria are considered in the evaluation of alternatives, and that the different criteria are weighted according to their degree of importance (Von Gadow, 1986). The method has been used extensively by many workers in a variety of forestry planning situations (Kroth *et al.*, 1976; Warkotsch, 1977; Von Gadow, 1981).

## Method of Paired Comparisons

The traditional forest mensuration techniques are not designed to assess judgemental information. Personal preferences are often considered intangible or irrelevant. One of the most popular methods for assessing the relative preference among a set of objectives is the method of paired comparisons.

In the method of pairing, 'n' criteria are usually lined up in  $[n * (n-1)]/2$  pairs. Each pair is then evaluated to establish a measure of preference of the one pair-item over the other. The method proposed by Ross (1934) is the most noteworthy among the various methods available for presenting the pair in some optimum order. The algorithm developed by Cloete *et al.* (1986) may also be used to produce optimum orders of pairs, similar to Ross's approach, for any number of criteria. Rose defined an optimum order as an arrangement, which is characterized by optimum balance and maximum spacing. These two conditions can only be met if n is odd number. If the number of criteria is even, optimum balance is impossible to achieve. However, the best order may be found by calculating the order for (n+1) items, then eliminating all the pairs containing the (n+1)'th item. In the method of pairing, we allocate preference index  $A_{ij}$  to each pair. The preference index is a subjective measure of the preference of criterion i over criterion j, using a predetermined rating scale.

There are a number of methods for calculating the normal criteria weights (Von Winterfeldt and Edwards, 1986). Two of the most prominent techniques of weight

$$M = \sum_{j=1}^n S_j + F$$

assessment are Zangemeister's (1976) "Nutzwertanalyse" (NWA) and Saaty's (1980) Analytical Hierarchy Process (AHP). Zangemeister's method is based on an interval scale while Saaty's method is based on a ratio scale. Here, we have used Zangemeister's method. In this technique for each criterion j, the sum  $S_j$  of the  $A_{ij}$  is determined. To ensure that negative weights do not occur, a factor  $F = |T| * (n-1)$  is added to the  $S_j$  where  $|T|$  is the absolute value of the highest possible score. Finally, the normalized weights are obtained by calculating

$$\text{and,} \\ W_j = (S_j + F)/M$$

Application example: CPT Selection in Tree Improvement programme

The following selection criteria are being followed in India for the selection of CPTs of tree species like *Tectona grandis*, *Dalbergia sissoo*, *Acacia nilotica* and *Eucalyptus camaldulensis* under planting stock improvement programme.

1. Total height (TH)
2. Bole height (BH)
3. Diameter at breast height (DBH)
4. Straightness (S)
5. Form & Shape (F & S)
6. Crown and branching (C & B)
7. Natural pruning (NP)



S		*		C & B
DBH	*			NP
BH	*			F/F
H			*	TH
F & S		*		C & B
S	*			NP
DBH	*			F & F
BH	*			H

**Procurement of Quality Seed and Raising of Seedlings in Nursery:** Import of quality seeds is not required for raising seedling seed orchard. We have selected 50 candidate plus trees (CPTs) of *Dalbergia sissoo*, 50 CPTs of *Acacia nilotica*, 30 CPTs of *Eucalyptus camaldulensis* in Rajasthan state. Seeds from 50 candidate plus trees of *Dalbergia sissoo*, 50 CPTs of *Acacia nilotica* and 30 CPTs of *E. camaldulensis* were collected and handed over to Silviculturist (SFD), Rajasthan and AFRI nursery for raising seedlings. Seeds of *E. camaldulensis* received from CSIRO, Australia and Coimbatore, India have also been handed over to the AFRI nursery for raising seedlings for SSOs. All the families were tagged individually and kept separately in the nursery. No special technique is required for raising seedlings of the targeted species.

**Preparation of Site and Design for Seedling Seed Orchards:** Sites at Govindpura Jaipur and Anupgarh, Ganganagar have been selected for raising SSO of targeted species. The area has been cleared levelled, ploughed and fenced with the barbed wire. Protected irrigation facilities have been installed. Designs for all selected species have been identified discussed and prepared. Since the Seedling Seed Orchards have been developed on the basis of Breeding Seedling Seed Orchards or Progeny Trial cum Seedling Seed Orchards the design used are based on Latinised Row Column Design with 5 number of seedlings per plot. In this case the number of replications have been increased which will help us in reducing the selfing in the seed orchards.

**Planting of Seedlings:** 15ha. of seedling seed orchard from 40 CPTs of *D. sissoo*, 10ha of SSO from 50 CPTs of *A. nilotica* at 5m row to row and 4m plant to plant and 6ha of *E. camaldulensis* at 4 m row to row and 2.5m plant to plant spacing have been planted at Govindpura, Jaipur. The remaining 10ha SSO of *A. nilotica*, 5ha SSO of *D. sissoo* and 2ha SSO of *E. camaldulensis* has been planted at Sangeeta Distributory and Anupgarh. The details of the seedling seed orchards established under FREEP are as follows.

S. No.	Species	Site Location	Design	Spacing (Row X Plant)	Area (ha)	Year of planting
1	<i>Acacia nilotica</i>	Govindpura, Jaipur, Rajasthan	Latinized Row-Column design	5x4m	10	1997-98
2	<i>Acacia nilotica</i>	IGNP, Rajasthan	Do	5x4m	10	1998-99
3	<i>Dalbergia sissoo</i>	Govindpura, Jaipur, Rajasthan	Do	5x4m	10	1997-98
4	<i>Dalbergia sissoo</i>	IGNP, Rajasthan	Do	5x4m	10	1998-99
5	<i>Eucalyptus camaldulensis</i>	Govindpura, Jaipur, Rajasthan	Do	4x2.5m	5	1996-97
6	<i>Eucalyptus camaldulensis</i>	IGNP, Rajasthan	Do	4x2.5m	3	1998-99

**Recording of observations:** This is not only a production seed orchard but will be used for the assessment of the CPT's progenies. The families will be on growth, form and quality of wood produce the main consideration, so that the "Elite" trees could be selected.

The growth data will be recorded after 6 months of planting for the survival of seedlings and accordingly mortality replacements will be done. Data will be recorded on yearly basis for growth characters, which includes: height, collar diameter, DBH, number of branches and branch angle. For form of the trees data will be recorded after 5 years on bole form: shape, taper, cross section, fluting and buttressing. The data on wood properties will be recorded at the half rotation age of the crop.

**Roughing of Seed Orchard:** On the basis of growth characters recorded and performance of individual families, the seedling seed orchard will be up graded by removing the inferior families. Simultaneously selection will also be made for the superior trees in the families to raise advance generation seed orchard.

The seed produced by these seed orchards fall in two categories of seed certification scheme. The seed collected from first generation seed orchard comes under the category "Reproductive material collected from untested seed orchards", & seeds collected from 1.5 & 2nd generation seed orchard comes under the category of " Tested Reproductive Material ".

#### **CRITERIA FOR THE SELECTION OF PLUS TREE OF *EUCALYPTUS* *CAMALDULENSIS***

- |    |                          |     |   |
|----|--------------------------|-----|---|
| 1. | Age and growth rate      | a)  | Minimum age 5 years.<br>Maximum age 15 years.                                     |
|    |                          | b)  | Superior in growth for height and diameter as compared to the check trees.        |
| 2. | Stem form                | a)  | Stem straight.  |
|    |                          | b)  | Leading shoot still making new growth.  |
|    |                          | c)  | Utilisable stem cylindrical.  |
| 3. | Crown & branching habits | a). | Narrow and compact.   |
|    |                          | b)  | 1/3rd of the total height of the tree.  |
| 4. | Health                   | a)  | Tree should be free from insect and fungal attack, freedom from gummosis of stem. |
| 5. | Seed bearing             | a)  | Capable of producing good and healthy seeds.                                      |

**Table 3.** List of candidate plus trees of *Eucalyptus camaldulensis* in Rajasthan State.

CPT No.	Height (m)	Clear Bole (m)	Girth/ (cm)	Range/Compartment/Area/Year of Plantation
EC-1	18.00	9.00	122.00	2MLD, Gharsana, Ganganagar, 1978
EC-2	21.00	12.00	131.00	237RD, Anupgarh branch, Gharsana, 1978
EC-3	20.00	12.00	164.00	do
EC-4	18.00	10.50	105.00	ORD, Sangeeta Distrib., Suratgarh, Left side, 1978
EC-5	22.00	10.00	182.00	0-1RD, do
EC-6	21.50	10.50	195.00	1RD, do
EC-7	23.00	16.00	196.00	1-2RD, do
EC-8	19.00	14.50	160.00	2RD, do
EC-9	21.00	14.00	117.00	2-3RD, do
EC-10	22.00	15.00	178.00	3-4RD, do
EC-11	21.50	10.00	154.00	4RD, do
EC-12	19.00	9.00	144.00	do
EC-13	21.50	10.50	196.00	4-5RD, do
EC-14	22.00	14.00	116.00	5RD, do
EC-15	22.50	14.50	181.00	5-6RD, do
EC-16	17.00	10.00	136.00	do
EC-17	25.00	20.00	125.00	7RD, do
EC-18	24.00	12.50	177.00	7RD, Right side
EC-19	21.50	13.50	128.00	6-7RD, Left side
EC-20	28.00	15.00	206.00	do
EC-21	24.50	16.00	118.00	6RD, Left side
EC-22	26.00	20.00	138.00	5-6RD, do
EC-23	25.50	14.50	157.00	5RD, do
EC-24	25.00	18.00	122.00	4-5RD, do
EC-25	22.00	14.50	157.00	4RD, do
EC-26	23.00	14.00	128.00	3RD, do
EC-27	24.00	15.00	152.00	0-1RD, do
EC-28	22.00	14.50	133.00	ORD, do
EC-29	21.00	7.00	159.00	264RD, Lunkaransar/ Burji lift nahar, 1978
EC-30	21.50	7.50	158.00	do

### CRITERIA FOR THE SELECTION OF PLUS TREE OF *DALBERGIA SISSOO*

1. Age and growth rate
  - a). Minimum age 15 years.  
Maximum age 50 years.
  - b). Superior in growth for height and diameter as compared to check trees.
2. Stem form
  - a). Clear bole up to 4-5 mts.
  - b). Leading shoot still making new growth.
3. Crown & branching habits
  - a). Spreading with branches.
  - b). 1/4th to 1/3rd of the total height of the tree.
  - c). Dense mass of healthy foliage.
  - d). Small branches at the point of origin.
  - e). Branch angle flattened to moderately ascending.
  - f). Good natural pruning and well healed knot scars.
4. Health
  - a). Tree should be free from insect and fungal attack
5. Wood properties
  - a). High ratio of heart wood to sapwood.
6. Seed bearing
  - a). Capable of producing good and healthy seed crop.

**Table 4.** List of candidate plus trees of *Dalbergia sissoo* in Rajasthan State..

CPT No.	Height (m)	Clear Bole (m)	Girth (cm)	Range/Compartment/Area/ Year of Plantation
DS-1	15.00	7.40	148.00	Kola, Hanumangarh,1969
DS-2	20.00	6.20	161.00	NDR, SH-7A, Hanumangarh -Rawatsar Road, 1969
DS-3	19.00	5.50	177.00	124-125, Suratgarh Branch, 1969
DS-4	18.00	5.30	164.00	5-6RD, Anupgarh branch, 1969, left side
DS-5	16.00	9.00	124.00	FWP2MLD, Gharsana, Ganganagar, 1975
DS-6	17.00	8.00	117.00	do
DS-7	16.50	8.50	107.00	do
DS-8	15.00	9.50	100.00	do

CPT No.	Height (m)	Clear Bole (m)	Girth (cm)	Range/Compartment/Area/ Year of Plantation
DS-9	17.00	8.00	111.00	do
DS-10	15.00	8.00	100.00	do
DS-11	12.00	5.00	104.00	2RD, Gharsana Distribut., Right side, 1975
DS-12	11.00	6.00	96.00	do
DS-13	14.00	8.00	126.00	3RD, do
DS-14	18.00	5.00	138.00	FWP9MD, Satrana, Gharsana, 1975
DS-15	18.00	4.50	140.00	FWP2GM, Gharsana, 1975
DS-16	20.00	8.00	146.00	Birdwall Head, Suratgarh, 1975
DS-17	18.00	5.00	144.00	do
DS-18	18.00	7.00	158.00	55RD, NDR, Hanumangarh, 1969, Left side
DS-19	20.00	5.00	189.00	51-52RD, do
DS-20	25.00	5.00	249.00	44RD, do
DS-21	23.50	6.50	193.00	43RD, do
DS-22	23.00	6.00	226.00	43RD, do
DS-23	22.00	7.00	205.00	41RD, do
DS-24	21.00	7.50	167.00	40RD, do
DS-25	22.00	7.00	210.00	36RD, do
DS-26	21.50	5.50	164.00	35RD, do
DS-27	16.00	5.50	155.00	30-31RD, do
DS-28	20.00	6.50	136.00	31RD, do
DS-29	21.50	6.50	228.00	38-39RD, Right side
DS-30	19.00	7.00	180.00	41RD, do
DS-31	18.00	7.50	176.00	52-53RD, do
DS-32	20.00	6.00	162.00	54-55RD, do
DS-33	18.50	7.00	168.00	SH-7A, Lakhwali to Hanumangarh Road, 1969
DS-34	18.00	5.00	120.00	5LK, Hanumangarh, 1966
DS-35	22.00	12.00	195.00	do
DS-36	18.00	6.00	129.00	do
DS-37	19.00	6.50	132.00	do

CPT No.	Height (m)	Clear Bole (m)	Girth (cm)	Range/Compartment/Area/ Year of Plantation
DS-38	19.00	7.00	119.00	do
DS-39	19.50	6.50	137.00	do
DS-40	19.00	7.00	127.00	do
DS-41	13.00	4.50	142.00	Maruthana, Biratnagar, Jaipur (E), 1960
DS-42	14.00	4.20	127.00	do
DS-43	17.00	4.80	164.00	SH-13, near school, Maruthana, Biratnagar, Jaipur (E), 1960
DS-44	15.00	4.00	162.00	SH-13, Shahpura to Alwar, near maruthana, B'nagar, Jaipur (E), 1960
DS-45	16.00	4.00	165.00	do, near Dahra village, 1960
DS-46	13.00	5.00	125.00	Sanjayvan, Shahpura, Jaipur(E), 1980
DS-47	13.00	7.00	12.00	Geejgarh, Sikrai, Dausa, 1965
DS-48	13.00	4.20	123.00	do
DS-49	13.50	5.50	100.00	do
DS-50	10.50	4.00	121.00	do

#### CRITERIA FOR THE SELECTION OF PLUS TREE OF *ACACIA NILOTICA*

1. Age and growth rate
  - a) 10 years or above.
  - b) Superior in growth for height and diameter as compared to the check trees.
2. Stem form
  - a) Utilisable stem cylindrical and straight more than 2.5m.
  - b) Leading shoots still making new growth.
3. Crown & branching habits
  - a) Spreading type.
  - b) Dense mass of healthy foliage for fodder. Pronounced branching.
  - c) Branch angle moderately ascending.
4. Health
  - a) Tree should be free from insect attack and Ganoderma.
5. Wood Properties
  - a) Higher ratio of heart wood to sapwood.
6. Seed bearing
  - a) Capable of producing good and healthy seed crop.

**Table 5.** List of candidate plus trees of *Acacia nilotica* in Rajasthan State.

<b>CPT No.</b>	<b>Height (m)</b>	<b>Clear Bole (m)</b>	<b>Girth (cm)</b>	<b>Range/Compartment/Area/ year of Plantation</b>
AN-1	15.00	7.00	94.00	FWP2MLD, Gharsana, Ganganagar, 1975
AN-2	18.00	5.00	118.00	do
AN-3	14.00	6.50	83.00	do
AN-4	12.00	5.00	100.00	do
AN-5	16.00	4.00	142.00	223RD, Anupgarh Branch, Right side, 1978
AN-6	18.00	5.00	116.00	222RD, do
AN-7	19.00	6.20	145.00	do
AN-8	16.00	7.00	112.00	218RD, do
AN-9	17.00	3.50	167.00	do
AN-10	15.00	5.20	145.00	227RD, Left side, do
AN-11	16.00	4.50	167.00	229RD, do
AN-12	16.00	4.00	125.00	do
AN-13	15.00	4.00	115.00	230RD, do
AN-14	19.00	7.00	109.00	238RD, do
AN-15	14.00	3.50	102.00	239RD, do
AN-16	15.00	5.00	91.00	do
AN-17	16.00	5.00	118.00	do
AN-18	14.00	4.00	87.00	do
AN-19	12.00	5.00	116.00	0RD,GD, Gharasana, 1978
AN-20	15.00	4.00	156.00	4RD, do
AN-21	22.00	6.00	144.00	Satrana minor, 12RD, Gharsanarworks
AN-22	21.00	10.00	106.00	do
AN-23	19.00	6.00	135.00	STR minor, 1RD, Left side, 1975
AN-24	16.00	4.00	117.00	2RD, do
AN-25	18.00	5.00	108.00	do
AN-26	18.00	4.00	113.00	do
AN-27	18.00	8.00	97.00	do
AN-28	21.00	6.00	145.00	3RD, do
AN-29	19.00	4.00	112.00	3RD, Right side near School
AN-30	18.00	4.00	118.00	do
AN-31	16.00	5.00	119.00	FWP9MD, Satrana, 1973
AN-32	20.00	5.00	129.00	do
AN-33	18.00	4.00	152.00	do
AN-34	18.00	5.00	147.00	do
AN-35	16.00	4.00	118.00	do
AN-36	12.00	3.30	119.00	FWP2GD, Gharsana, 1975

CPT No.	Height (m)	Clear Bole (m)	Girth (cm)	Range/Compartment/Area/ year of Plantation
AN-37	20.00	4.00	166.00	RD7, GM, Gharsana, Left side, 1978
AN-38	18.00	4.00	137.00	7-8RD,GM, Left side
AN-39	18.00	4.75	110.00	do
AN-40	16.00	4.50	116.00	FWP2GM, Gharsana, 1978
AN-41	12.00	2.80	122.00	NH-11, near 3-4 Km mark of Bassi chak, Kheda, Jaipur (E), 1985, Onkar ji fields.
AN-42	11.50	2.75	124.00	Navneet Natural Hospital, Bassi chak, Kheda, Jaipur (E), 1985.
AN-43	14.00	2.80	118.00	Farmer's field, NH-11 near Reta village, Bassichak, Jaipur (E), 1983.
AN-44	14.00	2.90	116.00	Bachhrain, Nadwai, Bharatpur, 1979.
AN-45	12.00	2.85	99.00	do, 1985
AN-46	10.00	2.50	86.00	do
AN-47	11.00	3.25	91.00	do
AN-48	12.00	2.85	92.00	do
AN-49	11.00	2.60	100.00	do, 1979
AN-50	14.00	2.80	116.00	do

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