PLANTING STOCK IMPROVEMENT
DEVELOPMENT OF SEED PRODUCTION AREAS (SPAs) IN RAJASTHAN AND GUJARAT STATE

Species *: Eucalyptus camaldulensis var. camaldulensis, Dalbergia sissoo* Roxb., *Tectona grandis* L.f. and *Acacia nilotica* (L.) Willd. ex Del.

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Introduction

Nature has endowed India with vast forest wealth of great diversity, varying from tropical evergreen forests to dry alpine forests containing over 300 genera and 700 species of forestry value. Due to the large geographical extension and the number of people involved in their use and management, forest resources are essential ingredients in any strategy for sustainable national development. These resources are depleted day by day due to over -exploitation. To meet the ever-increasing demand of the forestry species for human needs, it is essential to increase the production of our forest plantations.

The challenge for meeting these increasing demands can be tackled through sustainable improvement of land and appropriate forestry development strategies. Intensive plantation forestry and clonal planting stock, backed up with sound silvicultural practices and long-term breeding strategies, will play a crucial role in improving land productivity and securing future wood supplies. Poor genetic quality of plants will adversely affect the productivity of scarce land resources throughout the rotation period and yield poor quality produce with low-returns. Therefore, for taking full advantage of geo-climatic conditions and productivity potential of the plantation sites, the genetic qualities, growth rates, forms, disease resistance and adaptability of planting stock must be of highest order.

Most tree species reproduce naturally by seeds and growing of seedlings is most commonly adopted method in afforestation and reforestation programmes than any other method of propagation. Generally trees are heterozygous and cross-pollinated and have considerable potentiality for genetic variability. Consequently, seedling production may result in variability among plants and the inability to transmit specific characteristics from seed-source tree to offspring. These characteristics present the importance of careful seed selection practices and use of high quality seeds in the success of plantation programmes.

All tree improvement programmes should have seed production at some stage of their development if continued gains are to be achieved. This is true even for programmes using vegetative propagules for large-scale operational planting. Seed is needed for the development of outstanding trees from which vegetative propagules can be obtained.

There are several methods that can be used to obtain genetically improved seed for immediate planting. These are usually interim in nature in that they are used only until the more permanent seed source becomes available. Often seeds from the interim procedure will not yield large-volume gains. If seed is needed immediately for an operational programme, one viable approach is to select outstanding phenotypes from natural stands or plantations and collect seeds from only these marked trees. Knowledge of the genetic parameters within a species is helpful for developing effective tree improvement/breeding strategies. The significance of genetic variation studies and provenance testing in forest tree improvement is well known. For example, a great variability, exists in the growth and stem -form of *D. sissoo*. This variation indicates that it is possible to improve this species by selection and breeding.

In broad sense, tree improvement covers both the selection of population (species, provenance, seed stands) and the selection and breeding of individuals. It comprises the identification of superior phenotypes, testing of their offspring in progeny trials to confirm genetic superiority of the parents, and bringing together tested superior genotypes for seed production to which both male and female parents contribute their superior genes.

The use of appropriate germplasm is fundamentally important for the entire tree planting activities. Although it is widely understood that tree species differ in site requirement and uses, the extent of genetic variability within species has been less appreciated. The vast natural genetic variation found within most of the trees is a resource to be wisely used. Investment in tree improvement programmes has proven to be one of the most cost-effective trees planting activities in temperate countries. Tropical field trials have demonstrated that yields can be increased between 10 to 45 percent by simply choosing the best-adapted seed source for a particular site. Further gains are possible from individual selection and breeding.

Tree improvement is a stepwise process involving exploration, collection, evaluation, breeding, multiplication, distribution and conservation of genetic resources. A successful tree improvement programme begins by defining the traits that need improvement.

Developing seed production areas (SPAs) is one of the first steps in tree improvement programme that can be used to obtain genetically improved seed for immediate planting. Though seeds obtained from this method do not yield large volume of genetic gain, it sometimes significantly improves tree quality.

The target assigned to AFRI for developing SPAs of various species under Planting Stock Improvement Programme of WB-FREE project is 200ha. This report will focus on key aspects of the survey, establishment, analysis and management of seed production areas of *Acacia nilotica*, *Dalbergia sissoo*, *Eucalyptus camaldulensis* and *Tectona grandis* in Rajasthan and Gujarat States.

The states profile

Gujarat State:

The state of Gujarat is situated between the latitude of 20^{o} 1' N to 24^{o} 7' N and longitude of 68^{o} 4' E to 74^{o} 4' E. The geographical area of the state is 1,96,024 sq. km. The climate of the state is tropical; however, the same is considerably moderated due to the long coastline. The temperature ranges between 1^{o} C to 46^{o} C, the variations are less in south Gujarat and in coastal zones but high in Northern and Saurashtra region. The rainfall received in the state varies from region to region, and on the basis of rainfall received, the state has been divided into 8 agro-climatic zones, as given in table 1.

Table 1. Agro-climatic zones of Gujarat

Zone	Name of Zone	Reported area (in 00 ha)	Percentage to total area
A.	Heavy rainfall zone of South Gujarat (Average annual rainfall 1500 mm and above) I: Sub-Zone hilly areas II: Sub-Zone plain areas	 6,300.7 2,748.9	 3.43 1.50
B.	Moderate to heavy rainfall zone of South Gujarat (Average annual rainfall 1000-1500 mm)	10,290.8	5.61
C.	Moderate rainfall zone of Central Gujarat (Average annual rainfall 800-1000 mm)	22,312.1	12.15
D.	Dry zone of North Gujarat (Average annual rainfall 7625-875 mm)	22,986.9	12.53
E.	Arid zone of North-West Gujarat (Average annual rainfall 250-500 mm)	57,462.8	31.32
F.	Arid cum dry zone of North Saurashtra (Average annual rainfall 400-700 mm)	34,966.9	19.06

G.	South Saurashtra zone (Average annual rainfall 750-1000 mm)	16,747.4	9.14
H.	Bhal and Coastal areas zone (Average annual rainfall 625-1000 mm)	9,679.0	5.27

The land use pattern in Gujarat is tabulated below (table 2):

Table 2. Land uses pattern in Gujarat

S. No.	Land Use	Area in Sq. km
1.	Forest	18872
2.	Barren and uncultivable lands	26050
3.	Land put to non-agricultural use	11271
4.	Cultivable waste	19769
5.	Permanent pasture and other grazing lands	8485
6.	Land under miscellaneous tree crops and other grooves not included in net area sown	40
7.	Current fallow	7372
8.	Other fallow	275
9.	Net area sown	96087

Source: Socio-economic Review, 1994-95, Gujarat State

Human Population: Gujarat ranks tenth in respect of human population in the country. According to 1991 census the population of Gujarat State is 4.13 crore which makes about 4.88% of total population of India. In 1991, the population density in the State was 211 persons per Sq. Km as against 250 persons per Sq. Km for the country. Of the total population, about 2.72 crore (65.71%) is rural population. The proportion of urban population (34.29%) is more than the national average of the country (25%). Gujarat state ranks 4th, in India, as far as urbanization is concerned. The growth rate is 21.19 % as against national average of 23.85%. The vulnerability of the state and recurrence of drought causes large-scale migration of livestock from one region to other region. The fodder and shelter demands of the livestock poses serious threat to natural forests and young plantations.

The economy of state is primarily based on Agriculture. The uncertainty of monsoon and its consequent effect on Agriculture often governs the contribution of this sector to state economy. Overall the contribution of the secondary sector has been largely on a level path whereas the tertiary sector has shown a progressive increasing trend. The industrial structure in the state has been gradually diversifying with the development of the industries like Petrochemicals, Chemicals and Fertilizers, Engineering and Electronics etc.

Forests

Forest Cover: The recorded forest area of Gujarat is 19,393 sq. km, which constitutes 9.89 % of the total geographical area of the state. However, the actual vegetal cover of the state is 12,578 sq. km., constituting 6.4 % of the geographical area. Forests in Gujarat are mainly found in southern and eastern belts of the State. The per capita forest area in the state is 0.05 ha, against the national average of 0.11 ha. Gujarat is one of the few states in the country, which has shown a continuous increasing trend in the forest cover of the state since 1989. The forest cover in the Gujarat state as per the 1997 Forest Survey of India (FSI) assessment (area in square kilometers) is shown in the table 3.

Table 3. Forest cover in Gujarat State (area in square kilometers)

District	Geographical area	Dense forest	Open forest	Mangrove	Scrub	Total
Ahmedabad	8707	8	45	-	92	53
Amreli	6760	107	84	-	53	191
Banaskantha	12703	433	313	-	247	746
Bharuch	9038	730	483	13	143	1226
Bhavnagar	11155	29	92	20	149	141
Gandhinagar	649	3	6	-	1	9
Jamnagar	14125	21	138	118	81	277
Junagarh	10607	1132	476	-	78	1608
Kheda	7194	-	40	-	36	40
Kachchh	45652	187	823	836	537	1846
Mehsana	9027	-	32	-	92	32
Panchmahals	8866	396	613	-	475	1009
Rajkot	11203	4	76	-	67	80
Sabarkantha	7390	370	305	-	285	675
Surat	7657	907	384	4	41	1295
Surendranagar	10489	10	61	-	217	71
The Dangs	1764	1008	500	-	2	1508
Vadodara	7794	206	293	-	163	499
Valsad	5244	786	486	-	21	1272
Total	**196024**	**6337**	**5250**	**991**	**2780**	**12578**

Source: State of Forest Report 1997, FSI, Dehradun.

Forest type: The wide variations in Geo-physical and Eco-climatic conditions ranging from hot saline desert to humid hilly tracts and from coast to high hills have resulted into formation of various types of forests. The forest areas of Gujarat are unevenly distributed. The major concentration of forests is found all along the eastern border of the state and the hilly portion of Saurashtra. The forests are found mainly in the districts of Dangs, Valsad, Surat and

Junagadh. As per the forest classification (Champion and Seth, 1968), following four forests types, out of 16 major types found in the country, are found in Gujarat:

Type 3B Tropical Moist Deciduous Forest
Type 5A Tropical Dry Deciduous Forest
Type 6B Northern Tropical Thorn Forest
Type 4B Littoral and Swamp Forest

Rajasthan State:

Rajasthan is the second largest state in the country. It lies between 23^{o} 30' and 30^{o} 11' North latitude and 69^{o} 29' and 78^{o} 17' East longitude. The geographical area of the state is 34.22 million hectare, which is 11% of the country's geographical area. There is marked difference in the physiographic features of the state. The Aravallis, one of the oldest mountain systems, divide the state into two unequal parts. The Aravallis cover over 30% of the state. A vast expanse of arid and semi-arid tract lies in the west of the Aravallis. The Vindhyan hill system, another important hill ranges in the southeast of the state, drains into Chambal and Banas rivers. In the fragile sedimentary tracts of these rivers, ravine formation is a very serious problem.

The physiography of Rajasthan is the product of long years of erosion and deposition processes. The present landforms and drainage systems have been greatly influenced and determined by the geological formations and structures. Four major physiographic regions can be identified within the state, as described below:

1. **The Western Desert:** Arid landscape, barren hills, level rocky structural plains, and other sandy plains characterize this region with alluvium layers underneath, sandy hummocks and low sand streaks, sand dunes of various kinds and inter-dunal plains. Most of the western sandy plain is covered with a thick mantle of aeolin sand, visible in the form of shifting and permanent sandy dunes.
2. **Aravalli Hills:** This constitutes the most dominant hilly area of Rajasthan. The ranges run diagonally across the state in the south-west to north-east direction starting from Gujarat and ending in Delhi, covering a distance of about 690 kms. Within Rajasthan, the ranges run from Khedbrahma in the south-west to Khetri in the north-east for a length of about 550 kms. Apart from the hills, other major landforms within this region are the rocky uplands, shallow to moderately deep alluvial plains and narrow alluvial plains at few locations.
3. **The Eastern Plains:** It covers most parts of Alwar, Bharatpur, Jaipur, Dholpur, Tonk,

Sawaimadhopur, Bundi and Kota districts. The eastern plains have rich alluvial soils drained by seasonal rivers. The eastern plains have two zones described as under:

The Banas Plains

This region is a broad plain having an altitude of 150 to 300 m above mean sea level (MSL), with a slope towards east. This plain is drained by Banas River. The area of Bhilwara, Tonk, Ajmer, Jaipur, Dausa and Sawaimadhopur districts falls within the catchment of Banas River. The alluvium deposits become thin towards west where the plain is higher and more irregular, while in the east the thickness of alluvium increases. The Banas plains present a wide spectrum of situations. Some of these areas are badly degraded, whereas, other support good forests of dry deciduous type.

The Chappan Plains

The plain lies in the south east of Udaipur, Banswara and Dungarpur district and southern part of Chittorgarh district. The tributaries of Mahi River drain the area. This ecosystem is facing a problem of siltation because of heavy soil erosion taking place in the higher hilly areas of the Aravallis. The accelerated pace of siltation of riverbeds and reservoirs is causing extensive damage to irrigation and agricultural production system. The area required immediate action to protect the land and water resources.

4. **The South-eastern Plateau:** Southern and south-eastern Rajasthan is mostly a plateau. The Hadoti plateau has intrusions of black volcanic rocks and the Vindhyan extensions covering most parts of Jhalawar, Baran and Kota districts. The Malwa plateau also extends into the southern parts of Chittorgarh and Banswara districts.

Eco-systems: A variety of fragile ecosystems exist in Rajasthan. The fragile ecosystem of Rajasthan are confronted with many problems related to desertification, deforestation, land degradation, ravine formation, etc., which are some of the peculiar problems in the state. It requires strong commitment, adoption of effective policies, strategies and institutional mechanism for proper implementation of suitable action plans and programmes. Classification of major Ecosystems is given in table 4.

Table 4. Major ecosystems of Rajasthan

S.No.	Ecosystem		Sub-type
I	Desert Ecosystem	i	Canal command area
		ii	Non-command area
		iii	The Luni basin
II	Aravalli Hill Ecosystem	i	Northern Aravalli region
		ii	Central Aravalli region
		iii	Southern Aravalli region
III	Eastern Plains Ecosystem	i	Banas basin

		ii	Mahi basin
		iii	Banganga basin
		iv	Sahibi basin
		v	Gambhiri basin
		vi	Varah/ Barah basin
IV	Hadoti plateau and Ravine Ecosystem	i	Chambal basin

Agro-climatic zones: The state is divided into nine agro-climatic zones. The districts falling under different zones are given in table 5.

Table 5. Districts falling under agro-climatic zones

Zones	Districts
Arid western plains	Jaisalmer, Western Barmer, Western Jodhpur, Bikaner, Western Churu and Rajasthan Canal Command Area
Irrigated North-western plains	Ganganagar, Western Bikaner and Western Jaisalmer
Transitional plains of inland drainage	Eastern Jodhpur, Nagaur, Eastern Churu and North Western part of Alwar
Traditional plains	Jalore, Pali, Eastern Sirohi, Eastern Barmer and Eastern Jodhpur
Semi-arid Eastern area	Ajmer, Jaipur, Sawaimadhopur and Tonk
Flood prone Eastern plains	Eastern Alwar, Bharatpur and Southern Sawaimadhopur
Sub-humid Southern plains	Aravalli hills in Eastern Sirohi, Udaipur, Bhilwara and Chittorgarh
Humid Southern plains	Dungarpur, Banswara, South-Eastern parts of Udaipur and Southern parts of Chittorgarh
Humid South-Eastern plains	Dungarpur, Kota, Bundi, eastern Chittor, South-Eastern Tonk and Western Sawaimadhopur

Source: Status of social forestry in Rajasthan. AFC core group report, 1991.

Geology and soils: Rajasthan is endowed with continuous geological sequences of rocks from the oldest Archaen Metamorphites, represented by Bhilwara Super Group to sub recent alluvium and wind blown sand. Bhilwara Super Group is more than 2500 million years old. The western and north-western parts of the state are covered by vast blanket of unconsolidated deposits including the blown sand of the Thar Desert. The remaining area exposes wide variety of hard rocks, which includes various types of metamorphic schist, quartzite and marbles of Pre-Cambrian age with associated acid and basic intrusive rocks. The sedimentaries include the rocks of Aravalli Super Group, Delhi Super Group, upper Pre-Cambrian, Vindhyan Super Group and of Cambrian to Jurassic, Cretaceous and Tertiary periods. The south-eastern extremity of the state is occupied by a pile of basaltic flows of Deccan Traps of Cretaceous period.

The Great Boundary Fault, through which river Chambal has carved its course, passes through south-eastern parts of the state. This fault is visible at Begun in Chittorgarh district and

northern parts of Kota. This fault reappears again in Sawaimadhopur and Dholpur districts.

The soils of Rajasthan are complex, highly variable, reflecting a variety of parent materials, physiographic land features, range of distribution of rainfall and its effects, etc. However, broadly, the soils can be put in five major groups, based on the basic fabric of soils, i.e. soil texture, which governs its many other properties. They are, (i) Sandy soils or light soils, (ii) Sandy loam or light medium soils, (iii) loam or medium soils, (iv) clay-loam to clay or heavy soils and (v) skeletal soils or shallow rocky and hilly soils. As such, these different soils create different types of habitats for plant growth, and therefore, the choice of trees and afforestation patterns on such kind of soils vary greatly. Soils are, thus, variable in their soil-water plant relationship, conservation needs and production potentials.

Climate: The climate of Rajasthan varies from semi-arid to arid. Hyperthermic conditions prevail in whole of the state. At some of the places the mercury touches 49^{o}C during summer and drops below freezing point during winter. The rainfall pattern of the state is very erratic. Though the average annual rainfall ranges between 200-400 mm, the annual rainfall received is as low as 150 mm in the extreme arid zones and as high as 1000 mm in the south-eastern parts of the state. Monsoon is active from July to September. The average number of rainy days varies from 6 to 42 depending on the aridity of the area.

The north-western part of the state falls under the hot arid eco-region and is having aeolian and saline soils. The growing period in the region is 90 days only. The Eastern part of the state, including the Aravallis, falls under hot semi-arid eco-region which has medium to deep alluvial and shallow in situ soils. The growing period in the region varies from 90 to 120 days. The south-eastern part of the state also falls under hot semi-arid eco-region having mostly shallow *in situ* soils and at places medium to deep alluvial soils with growing period varying from 90 to 150 days.

Scanty and unevenly distributed rainfall, very few rainy days and extremes of very high and very low temperatures are the main causes of aridity in the state. Under such conditions vegetative growth is very poor and can mainly support zerophytic and bushy vegetation only.

Forests

Forest area and forest cover: The forests of Rajasthan are basically of five types (table 6) spread

unequally in northern, southern, eastern and south-eastern parts. The state has teak forests, which is northern most limit of teak zone in India. The forests are mostly edapho-climatic climax forests.

Table 6. Area by forest type

S.No.	Type	Forest Area (ha.)	% of total forest area
i	Dry teak forests	224,787	7.05
ii	Subsidiary edaphic type of dry tropical *Anogeissus pendula* forests	1,902,775	59.65
iii	Northern tropical dry deciduous mixed forests	864,322	27.09
iv	Northern tropical thorn forests	185,452	5.81
v	Sub-tropical evergreen forests	12,664	0.40
	Total	**3,190,000**	**100**

It is clear from the above table that nearly 87% forest area is under subsidiary edaphic type - dry tropical *Anogeissus pendula* forests and northern tropical dry deciduous mixed forest. These forests have primarily been managed initially under coppice with standard and later under coppice with selection silvicultural system mostly for fuelwood purposes.

The total forest area of Rajasthan is 9.32% of total geographical area of the state. 3.83% area has forest cover with crown density above 10% and only 1% area has good forest cover of crown density of 40% and above. Rajasthan is a forest deficient state and larger part of this state is part of the Thar Desert. Not only the climatic condition is very harsh but also the soil is equally impoverished. Due to these twin challenges, forestry is not an easy job. As agriculture is uncertain, people rear large cattle herds. The human to cattle ratio is 1:1 in this state, while the national average is 2:1. Thus the natural forests as well as plantations are subjected to heavy biotic pressure.

Methodology for the Establishment of Seed Production Areas of Acacia, Eucalyptus, Dalbergia and Teak in Gujarat and Rajasthan States

The Seed Production area (SPA) is defined as a phenotypically superior stand made up of vigorously growing healthy trees, upgraded by thinning to remove poorer phenotypes and treated and managed to cause abundant seed production.

An assessment of available plantations for their growth, form and preponderance of superior trees by sampling and ranking them, would help in selecting the best plantation for converting into SPA. To compare the plantations selected for conversion into SPA with the

plantations rejected, it is essential that some basis on growth and form be recorded for comparison of the stands. Since it is not possible to assess the whole plantation, it is recommended that 3 to 5 % sampling intensity may be followed for making comparison, though it depends on variability (homogeneous or heterogeneous plantations).

Seed stands are selected by surveying the plantation cover at least three times the area required for conversion into SPA. The Seed Production Area is established in different zones of the state based on the site quality and age of the plantation.

Seed stands after removal of inferior trees are termed as **Seed Production Area (SPA).** Seed production areas are rarely progeny tested; therefore, the parents are selected only on their phenotypic qualities. They are generally used as interim sources of seed in forest tree improvement programmes and are phased-out as better genetic seed becomes available from seed orchards. Seed production areas have greater utility in a number of tropical and sub-tropical countries. Seed stands of various target species surveyed, identified, marked and analysed and the method for establishment are reported here.

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, gobar (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, sometimes 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 and construction purposes. The bark is used for tanning in leather industries. Babul gum is used for various purposes and leaves are good fodders 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 *D. 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 timbers for 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 Camaldoli 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 -8^0 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 till four to seven days later. As the stigma is not sticky, it 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 all the flowers in the same flower cluster and in the clusters in different parts of the crown do not open simultaneously, a considerable amount of self-pollination is known to occur within one tree despite 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 fertilising 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.

Teak (*Tectona grandis* Linn. F.), belonging to the family of Verbenaceae and having chromosome number 2n = 36, is a native to the Indo-Malayan region and occurs naturally in some parts of India while in many others it has been planted. It produces one of the world's most valuable timbers of outstanding durability. Five teak-forest types have been recognised in India. They are namely- very moist, moist, semi-moist, dry and very dry.

The name Tectona has been taken from the Portuguese word teca, which is a derivative of Greek word tekton, meaning a carpenter. Grandis in latin stands for large and as the qualities of teak wood are much appreciated by carpenters the literal meaning of teak (*Tectona grandis*) as carpenter's pride holds most appropriate. Teak is a unique species whose timbers are most aristocrats amongst the timbers of India. Its durability is the gift of nature bestowed upon it. The other qualities are due to its matchless properties such as termite, fungus and weather resistance, lightness with strength, attractiveness, workability and seasoning capacity without splitting, cracking or materially altering shape. Its wood is also used for ship building, bridge building, piles, furniture, cabinet work, railcars, wagons, wheel spokes and general carpentry.

Teak is a light demander; it does not tolerate suppression at any stage of its life and requires complete overhead light as well as fair amount of side room for its proper development. Teak is a deciduous tree, shedding its leaves from November to January and remaining leafless throughout the greater part of hot season. New leaves appear from April to June. Teak is capable of thriving on variety of soils and geological formations, but requires good sub-soil drainage. Teak produces large deep root system and sensitive to frost. It coppices vigorously. Teak is hermaphrodite and flowering is generally in panicles of small white flowers. Inflorescence is large, dichotomously branched and terminal tomentose cymose panicle type. Flowering season varies from June to August or September and fruits ripen from November to January. However, In southern part of India, flowers are seen in December-January and fruits ripen in April-May. In teak lot of natural variation is available due to its wide distribution within India and in other countries. Variation is the most important genetic resources for bringing in genetic improvement in species. Therefore, there is plenty of scope to improve teak through selection and hybridisation. Advance techniques like mutation, polyploidy, biotechnology and genetic engineering can be of immense use for the genetic improvement of teak.

In teak, there is evidence of inherent variation in stem straightness, size, shape, colour and texture of the leaves, winter susceptibility, resistance to insect and pests and site requirements.

Collection of information about potential Seed Stands: The State Forest Department of Rajasthan and Gujarat provided the list of potential seed stands of *Acacia nilotica, Dalbergia sissoo, Eucalyptus camaldulensis* and *Tectona grandis* to consider them for conversion into SPAs after survey and selection.

Finalisation of methodology for the establishment of seed production areas: The scoring of the trees has been done for both qualitative and quantitative traits. The traits selected for scoring are:

- Total Height
- Bole Height
- Diameter/Girth at breast Height
- Form/Straightness
- Crown and branching
- Natural pruning ability
- Flowering and fruiting
- Insect/pest/disease

The first three traits are quantitative measurements with high degree of heritability and higher correlation with volume production, whereas the rest of the traits are subjective assessments. The point grade method has been followed for scoring the above traits. The maximum score a tree can have in this method is 100. The traits such as Total Height, Bole Height and DBH/GBH have been given maximum score of 76, as these are the primary economic traits with high heritability.

Forest managers are often more interested in estimating tree volume with greater accuracy as it is commercially an important character and information regarding volume production is very much required for future management of the tree stands/forests. Total wood volume (V) for each tree of different species was computed using the equations given below.

E. camaldulensis	$V = -0.00308 + 0.0000333\ D^2H$
D. sissoo	$V = -0.00260 + 0.0000365\ D^2H$
A. nilotica	$V = 0.00208 + 0.0000412\ D^2H$
T. grandis	$V= 0.12170 + 0.0000226\ D^2H$

Where V = Volume in m^3; D = Diameter at breast height; H = Total height

The guidelines and methodology for establishment of seed production areas were circulated to us by Sh. K. Subramanian, Chairman, Working Group on Seed Production Areas vide his letter no. DIR/V-10-3/97/335 dated 9.1.98. When we applied this technique for analysing the data collected from the sample plots laid out in the Seed Stands, we encountered with the problem that even some of the good areas selected ocularly were rejected in this method. When we tried to sort out this problem through careful examination of the methodology adopted, we found that equal scoring, with appropriate +ve and -ve signs, should have been given to the % superiority of measured traits above and below their mean value instead of the scoring proposed in the present methodology, which considered the scoring for the % superiority only with +ve sign in ascending order. Accordingly, we modified the scoring sheet and these are given in table 7.

Table 7. Scoring for total height and bole height in a sample plot.

Scoring for Total Height/GBH		**Scoring for Bole Height**	
% Superiority of each tree in the sample plot over average of sample plot	Score	% Superiority of each tree in the sample plot over average of sample plot	Score
< - 20	- 20	< - 25	- 36
- 16 to – 20	-16	- 21 to – 25	- 30
- 11 to – 15	- 12	- 20 to – 16	- 24
- 6 to – 10	- 8	- 15 to – 11	- 18
- 1 to – 5	- 4	- 10 to – 6	- 12
- 0.9 to 0.9	0	- 5 to – 1	- 6
1 to 5	4	- 0.9 to 0.9	0
6 to 10	8	1 to 5	6
11 to 15	12	6 to 10	12
16 to 20	16	11 to 15	18
> 20	20	16 to 20	24
		21 to 25	30
		> 25	36

The total height, bole height and girth at breast height of all trees in each sample plot were

measured and average of each parameter in every plot was calculated. Scoring to each of these parameters were given on the basis of comparison of the population in the sample plot with the average. The trees measuring more than the averages were given positive scoring while trees showing less values than the averages were assigned negative values (from + 20 to - 20 for girth at breast height and total height and + 36 to - 36 for bole height). The scores assigned to the various subjective parameters are given in tables 8 and 9. The scores of subjective as well as measured parameters were summed up for each plot and plots scoring highest number in descending order were identified as superior stands. The format used for the measurement of various traits is given in table 10.

Table 8 (a). Scoring for crown development in a sample plot.

Shape	Score
Narrow	1
Medium	3
Well developed	5

Table 8 (b). Scoring for form and straightness in a sample plot.

Character	Score	Character	Score
Straight	5	Round	5
Wavering	3	Medium fluting	3
Crooked	1	Heavy fluting	1

Table 9. Scores for other traits in a sample plot.

Character	Scoring range	Scores		
		1	2	3
Health	1-3	Heavy infestation	Moderate	Healthy
Natural pruning	1-3	No pruning	Medium	Self pruning
Flowering/fruiting	1-3	poor	Medium	Heavy

4. Survey and identification of seed stands: The enlisted and other areas have been surveyed jointly with officials of SFDs (Table 11 and 12). The sample plots of 20m X 20m have been laid out in all the surveyed stands for inter comparison between seed stands for desirable traits. The traits measured were total height, bole height, girth, straightness, crown and branching, flowering and fruiting and health. After the analysis of sample plots, superior seed stands were identified for conversion in seed production areas (SPAs). All the selected seed stands were jointly enumerated and marked for further analysis, marking of inferiors and number of trees

to be retained and culled. All the sample plots were statistically analyzed and comparison was made between the seed stands. The areas reported in table 13 were marked jointly with the SFDs for conversion into SPAs of the target species. These areas have now been converted into SPAs as the culling in these areas has been completed.

Table 11. Seed stands of *Dalbergia sissoo, Acacia nilotica* and *Eucalyptus camaldulensis* in Rajasthan State

S.No.	Species	location	Area (Ha.)
01	*Dalbergia sissoo*	Gharsana distributory, 0-22RD, Right bank, Gharsana, Ganganagar, 1975	20.0
		Right bank of Gharsana Distributory, FWP-2GM Ganganagar, 1975	12.0
		Navrangdesar Branch 0-55RD, Hanumangarh, 1969	50.0
		5LK, Hanumangarh, 1966	
		Part of Kola Block, 12AKSP, Hanumangarh, 1966	24.0
		Part of Kola Block 12A, Kisanpura, Hanumangarh, 1969	25.0
		Left bank of Suratgarh branch, 120-137RD, Suratgarh, Ganganagar, 1968	25.0
		Sanjay Van, Shah pura, Jaipur (E), 1982	10.0
			15.0
		Total area	**179.0**
02	*Acacia nilotica*	Abadi land plantation 7GD, Gharsana, Ganganagar, 1975	8.0
		FWP-2GM Gharsana, Ganganagar, 1975	12.0
		Gharsana minor, 0-22RD, Both side, Gharsana, Ganganagar, 1978	25.0
		Left bank of Anoopgarh Sakha near old Gharsana mandi Nursary, Gharsana, Ganganagar,1978	55.0
		Left bank of Suratgarh branch, Rawatsar, Hanumangarh,1978	10.0
		Right bank of Suratgarh branch 91-94RD, Suratgarh, Ganganagar,1975	15.0
		Left bank of Suratgarh branch, 120-137RD, Pilibanga, Ganganagar, 1977	25.0
		Mandera beed, Deeng, Bharatpur, Natural	100.0
		Total	**250.0**
03	*Eucalyptus camaldulensis*	Right bank of Gharsana distribu., 0-22RD, Ganganagar, 1975	20.0
		96-98RD, MC, left bank, Rawatsar, Hanumangarh, 1981	5.0
		Left side of Suratgarh branch RD91-94, Hanumangarh, 1978	5.0
		Kola block, Hanumangarh, 1975	15.0
		Sangeeta distributory, 0-7RD, Suratgarh, Ganganagar, 1978	10.0
		Left side Anoopgarh Sakha, 10-12RD, Suratgarh, Ganganagar, 1975	10.0
		Total	**65.0**

Table 12. Seed stands of *Acacia nilotica* and *Tectona grandis* in Gujarat State.

S.No.	Species	location	Area (Ha.)
1.	*Acacia nilotica*	Pawagarh, Godhra	100.0
		Nagina, Godhra	50.0
		Panam project, Gushar, Godhra	50.0
		Thasra, Umreth, Nadiyad	25.0
		Shivrajpur, Kheda, Nadiyad	20.0
		Sasangir, Junagarh	10.0
		Deshalpur, Bhuj	15.0
		Total	**270.0**
2.	*T. grandis*	Achhala, Godhra	200.0
		Chikhali, Dungarda, Dangs south	50.0
		Dumka, Lalwada, Baria	100.0
		Sathakashi, Vyra, Surat	10.0
		Limbani, Chhota Udaipur	50.0
		Pada, Sagbara, Rajpipla, East	50.0
		Balsad, Surat	25.0
		Rambhas, Dungarda, Dangs South	20.0
		Beskatri, Dungarda, Dangs south	100.0
		Malangdev, Vyra, Surat	25.0
		Gaven, Vyra, Surat	100.0
		DevMongra, Piploid, Rajpipla East	100.0
		Jambugoda Chhota Udaipur	50.0
		Limkheda, Baria	20.0
		Parnera, Valsad	40.0
		Total	**940.0**

Table 13. Identified seed stands converted into seed production areas.

State	Species	Location	Area (ha)
Rajasthan	*E.camaldulensis*	0-7 Sangeeta Distributory, Surat garh	10.0
	Acacia nilotica	Mandera Beed, Bharatpur	15.0
	Acacia nilotica	0-22RD, GM, Gharsana	20.0
	Dalbergia sissoo	40-55RD, NDR, Hanumangarh	20.0
	Dalbergia sissoo	Shah pura, Jaipur East	10.0
Gujarat	*Acacia nilotica*	Pawagarh, Godhara.	15.0
	Acacia nilotica	Gusar, Godhara	25.0
	Tectona grandis	Limbani , Chhota Udaipur	10.0
	Tectona grandis	Chikhali, Dangs south	20.0
	Tectona grandis	Dumka, Lalwada, (Baria)	10.0
	Tectona grandis	Sathakashi, Vyra	05.0
	Tectona grandis	Parnera, Valsad	20.0
	Tectona grandis	Achhala, Godhara	20.0

Analysis of sample plots

(a) Comparison between seed stands:

Within a sample plot, all the trees were scored by the point grade method and the scores were summed up. The sum of all the scores of all the sample plots representing a plantation for the selected area were then totalled and the average score for the stand was calculated.

All these stands were then ranked in a descending order based on the average score of all the trees in the sample plots representing them. Then the stands, ranked highest, were selected for conversion into SPAs based on the area required meeting the seed demand.

Foe example, The average score of sample plots of seed stand of *Eucalyptus camaldulensis* situated at 0-7RD of Sangeeta Distributory on both sides has 18.88 (table 14). The other seed stands of *E. camaldulensis* have scored lower than this. Hence we have selected this stand for converting into seed production area. The mean values of the measured traits of the sample plot of each seed stand of other species are given in the tables (15, 16, 17 and 17). On the basis of the ranking and the need of the forest department, various seed stands of target species were selected for conversion into SPAs.

Table 14. Comparative Assessment of Seed Stands of *Eucalyptus camaldulensis*

Seed stands	Plot No.	No. of Trees	Average Height (m)	Average Clear Bole (m)	Average Girth (cm)	Average Score
0-7RD, Sangeeta Distributory,	1	15	15.56	5.78	91.20	17.53
Suratgarh, Ganganagar, 1978.	2	15	18.32	5.84	123.80	18.00
	3	15	20.36	4.93	145.86	19.60
	4	15	17.93	5.87	115.20	20.40
Average			**18.04**	**5.61**	**119.02**	**18.88**
0-22RD, Gharsana Distributory, 1975	1	15	17.00	4.76	130.80	15.26
	2	15	18.26	3.90	136.93	17.06
	3	10	17.62	3.62	138.28	16.14
Average			**17.63**	**4.09**	**135.34**	**16.15**
12 AKSP, Kola Block, (1975)	1	10	18.20	2.89	88.13	14.46
	2	10	18.04	3.71	79.15	12.03
	3	10	16.13	2.70	81.86	4.07
Average			**17.46**	**3.10**	**83.05**	**10.19**

96-98RD, Rawatsar, (1981)	1	10	18.22	3.18	125.80	13.29
	2	10	17.87	1.51	130.27	7.02
	3	10	19.16	1.67	156.23	9.71
Average			**18.42**	**2.12**	**137.43**	**10.01**
10-12RD, Anupgarh Branch, 1978	1	15	17.00	4.76	130.80	9.66
	2	15	16.56	4.27	90.33	10.60
	3	15	19.25	3.66	109.80	8.40
Average			**17.60**	**4.23**	**110.31**	**9.55**
91-94 RD, Surat Garh Branch,	1	17	16.83	3.00	75.00	7.46
(Daultabad Dhani) ,1978	2	17	17.72	2.59	86.80	-0.53
	3	17	16.90	2.84	90.93	3.53
Average			**17.15**	**2.81**	**84.24**	**3.49**

Table 15. Comparative Assessment of Seed Stands of *Acacia nilotica*

Seed stands	Plot No.	No. of Trees	Average Height (m)	Average Clear Bole (m)	Average Girth (cm)	Average Score
Mandera Beed, Deeng,	1	10	16.00	2.10	106.00	39.90
Bharatpur, Natural, 100ha	2	9	14.00	1.90	102.00	55.40
	3	8	16.00	1.80	112.00	51.50
Average			**15.33**	**1.93**	**106.66**	**48.93**
0-22GM, Gharsana,	1	20	14.09	2.12	97.10	11.20
Ganganagar (1978)	2	20	15.75	2.44	92.90	16.60
	3	30	13.36	1.97	99.66	17.13
	4	12	15.40	2.04	110.58	13.58
Average			**14.65**	**2.14**	**100.06**	**14.62**
7GD, Gharsana,	1	15	16.08	1.58	87.53	15.80
Ganganagar (1975)	2	15	14.42	1.32	79.00	10.33
	3	15	13.83	1.38	84.66	13.60
Average			**14.77**	**1.42**	**83.73**	**13.24**
91-94RD, Right bank of	1	15	12.76	1.44	93.12	10.4
Suratgarh Branch,	2	15	14.36	1.88	73	10.93
Ganganagar (1975)	3	11	15.33	1.75	99.14	16.35
Average			**14.15**	**1.69**	**88.42**	**12.56**
Left bank of Anupgah	1	15	14.96	1.76	77.20	13.66

branh, near old Gharsana	2	15	16.60	1.78	97.26	8.06
mandi (1978)	3	15	14.49	1.80	102.20	10.26
	4	15	13.53	1.58	79.53	3.26
Average			**14.89**	**1.73**	**89.04**	**8.81**
FWP2GM, Gharsana,	1	15	13.55	1.31	81.40	8.26
Ganganagar (1975)	2	15	14.60	1.80	119.20	14.06
	3	15	15.19	1.71	91.93	3.33
Average			**14.44**	**1.60**	**97.51**	**8.55**
Branch, Rawatsar,	1	10	11.30	1.91	90.50	3.50
Hanumangarh (1978)	2	10	13.30	1.44	81.90	0.30
	3	10	15.83	1.49	98.30	12.80
Average			**13.47**	**1.61**	**90.23**	**5.53**
120-137Rd, Left Bank of	1	10	13.58	1.70	70.54	-1.66
Suratgarh branch,	2	10	14.07	1.71	85.11	11.16
Ganganagar (1977)	3	10	14.34	1.72	85.15	6.65
Average			**13.99**	**1.71**	**80.26**	**5.38**

Table 16. Comparative assessment of seed stands of *Dalbergia sissoo*

Seed stands	Plot No.	No. of Trees	Average Height (m)	Average Clear Bole (m)	Average Girth (cm)	Average Score
0-55RD, Navrang Deshar Branch,	1	15	16.40	4.14	136.75	22.13
Hanumangarh (1969).	2	15	16.92	4.01	155.27	18.53
	3	15	16.88	3.77	141.46	25.80
	4	15	17.56	3.56	140.60	33.33
	5	15	18.56	3.58	140.03	24.33
	6	15	18.02	3.74	161.67	20.06
Average			**17.39**	**3.80**	**145.96**	**24.03**
0-22RD, Gharsana Distributory,	1	15	14.36	1.75	79.77	12.86
Gharsana, Ganganagar (1975)	2	15	14.32	1.99	81.26	16.66
	3	10	15.34	2.29	105.23	20.82
Average			**14.67**	**2.01**	**88.75**	**16.78**
FWP2GM, Gharsana,	1	15	13.46	3.24	99.40	15.00
Ganganagar (1975)	2	15	14.45	2.65	109.45	20.53
	3	19	14.88	3.23	83.53	9.40

Average			**14.26**	**3.04**	**97.46**	**14.98**
12 AKSP, Part of Kola Block,	1	10	15.96	2.20	95.70	13.50
Hanumangarh (1966)	2	10	15.96	2.16	109.91	13.32
	3	10	15.99	2.29	102.35	18.32
	4	10	16.28	1.93	104.24	7.10
Average			**16.05**	**2.15**	**103.05**	**13.06**
Sanjayvan, Shahpura,	1	10	16.45	2.83	93.50	12.80
Jaipur (1982)	2	10	13.67	2.27	85.67	3.48
	3	10	16.04	2.34	92.76	17.24
Average			**15.39**	**2.48**	**90.64**	**11.17**
120-137RD, Suratgarh Branch,	1	10	15.19	2.20	128.60	7.40
Suratgarh, Ganganagar (1968)	2	10	15.51	2.29	141.61	15.02
	3	10	14.75	1.76	131.19	9.35
Average			**15.15**	**2.08**	**133.80**	**10.59**
5LK, Hanumangarh (1966)	1	10	15.98	3.04	128.28	-0.99
	2	10	15.23	3.14	91.37	10.00
	3	10	13.91	2.68	89.31	1.57
Average			**15.04**	**2.95**	**102.99**	**3.53**

Table 17. Comparative Assessment of Seed Stands of *Tectona grandis of Gujarat State*

Seed stands	Plot No.	No. of Trees	Average Height (m)	Average Clear Bole (m)	Average Girth (cm)	Average Score
Chikhli, Dang South	1	12	17.44	4.24	90.58	24.54
	2	10	16.94	4.03	92.80	56.54
	3	10	16.82	4.10	94.46	25.84
Average			**17.07**	**4.12**	**92.61**	**35.64**
Dhanpur (Dumka), Baria	1	10	16.48	3.13	78.88	31.00
	2	12	17.56	4.27	90.52	21.30
	3	10	16.09	4.03	91.32	18.30
Average			**16.71**	**3.81**	**86.91**	**23.53**
Sathakashi, Surat	1	18	13.69	3.96	48.33	17.00
	2	27	12.41	3.66	47.52	17.70
	3	15	13.84	4.43	51.40	24.90
Average			**13.31**	**4.02**	**49.08**	**19.87**
Limbani, Ch. Udaipur	1	11	16.32	2.83	73.09	17.82
	2	13	16.79	2.83	65.24	6.48
	3	11	17.74	3.61	85.78	28.55
Average			**16.95**	**3.09**	**74.70**	**17.62**
Parnera, Valsad	1	16	20.56	6.11	82.56	22.20
	2	16	20.00	6.23	71.88	22.80
	3	15	19.47	5.29	76.60	19.90

	4	20	15.75	4.56	33.80	8.55
	5	22	16.23	5.14	39.00	11.70
Average			**18.40**	**5.47**	**60.77**	**17.03**
Achhala, Godhra	1	18	12.89	2.64	65.06	15.00
	2	27	12.85	3.15	62.74	17.50
	3	22	13.84	2.64	60.00	14.30
Average			**13.19**	**2.81**	**62.60**	**15.60**
Balsad, Surat	1	13	14.82	2.67	57.98	8.82
	2	11	15.14	2.51	63.65	11.40
	3	11	17.10	2.83	76.19	13.90
Average			**15.69**	**2.67**	**65.94**	**11.37**
Pada, Rajpipla	1	18	14.20	2.32	61.94	9.61
	2	13	14.90	2.97	60.11	11.40
	3	14	14.52	3.11	62.65	13.00
Average			**14.54**	**2.80**	**61.57**	**11.34**
Malangdev, Surat	1	22	13.36	2.31	55.89	11.20
	2	18	12.89	2.67	65.06	8.19
	3	20	13.39	2.60	64.33	13.50
Average			**13.21**	**2.53**	**61.76**	**10.96**
Beskatri, Dang South	1	15	12.90	2.51	66.34	4.47
	2	15	13.32	2.68	61.78	12.50
	3	15	12.28	2.80	62.10	12.30
Average			**12.83**	**2.66**	**63.41**	**9.76**
Jambugoda, Ch. Udaipur	1	11	11.91	2.98	66.45	3.51
	2	13	12.77	2.42	63.15	9.57
	3	14	12.61	2.44	64.21	13.70
Average			**12.43**	**2.61**	**64.60**	**8.93**
Gaven, Surat	1	12	13.61	2.91	65.37	4.48
	2	10	12.88	2.63	56.96	12.00
	3	18	12.89	2.67	65.06	9.61
Average			**13.13**	**2.74**	**62.46**	**8.70**
Limkheda, Baria	1	9	11.78	2.68	64.33	3.35
	2	12	13.75	2.02	58.50	8.02
	3	14	12.17	2.52	59.50	13.50
Average			**12.57**	**2.41**	**60.78**	**8.29**
Rambhas, Dang South	1	12	15.22	2.78	77.42	-10.10
	2	10	14.37	2.37	62.91	17.90
	3	10	14.85	2.42	63.70	16.90
Average			**14.81**	**2.52**	**68.01**	**8.23**
Devmogra, Rajpipla	1	13	13.12	3.00	60.62	6.32
	2	14	12.61	2.76	64.71	7.09
	3	20	13.75	1.87	59.15	3.48
Average			**13.16**	**2.54**	**61.49**	**5.63**

(b) Comparison of trees within a stand selected for conversion into SPA and identification of trees for culling:

After selecting the stand/ plantation, all the trees in the whole of selected seed stand/plantation were numbered and each of the tree was scored for the traits as described above. These trees were ranked in descending order based on the scores obtained. Predetermined number of trees was selected from the top of this list and the remaining trees were culled out as the number of trees to be retained per hectare depends on the species, site quality and the age of the stand. When the selected trees were closely spaced than required for a SPA; some trees above the cut of point were also culled. Number of trees retained and culled is given in table 18.

Table 18. State, species, location, number of trees to be retained and culled in the identified seed stands.

State	Species	Location	No. of trees to be retained	No. of trees to be culled	Area (ha)
Rajasthan	*Eucalyptus camaldulensis*	0-7 Sangeeta Distributory, Surat garh	805	4500	10
	Acacia nilotica	Mandera Beed, Bharatpur	390	115	15
	Acacia nilotica	0-22RD GM, Gharsana	2500	1350	20
	Dalbergia sissoo	40-55RD, NDR	1052	490	20
	Dalbergia sissoo	Shah pura, Jaipur East	680	358	10
Gujarat	*Acacia nilotica*	Pawagarh, Godhara.	4212	1510	15
	Acacia nilotica	Gusar, Godhara	6479 & 7465	17650 & 13041	25
	Tectona grandis	Limbani , Chhota Udaipur	1000	493	10
	Tectona grandis	Chikhali, Dangs south	963	846	20
	Tectona grandis	Dumka, Lalwada, (Baria)	207	303	10
	Tectona grandis	Sathakashi, Vyra	2166	2013	05
	Tectona grandis	Parnera, South Valsad	4415	3334	20
	Tectona grandis	Achhala, Godhra	1900	2110	20

Analysis of seed stands before and after culling

Based upon the ranking arrived at after sample plot analysis, seed stands of *Eucalyptus camaldulensis* (10ha.), *Acacia nilotica* (35ha.) and *Dalbergia sissoo* (30ha) in Rajasthan and *A. nilotica* (40ha) and *Tectona grandis* (85ha.) in Gujarat state were identified for converting them into seed production areas. The details of the statistical analysis indicating changes in the parameters assessed before and after culling operation, is described here:

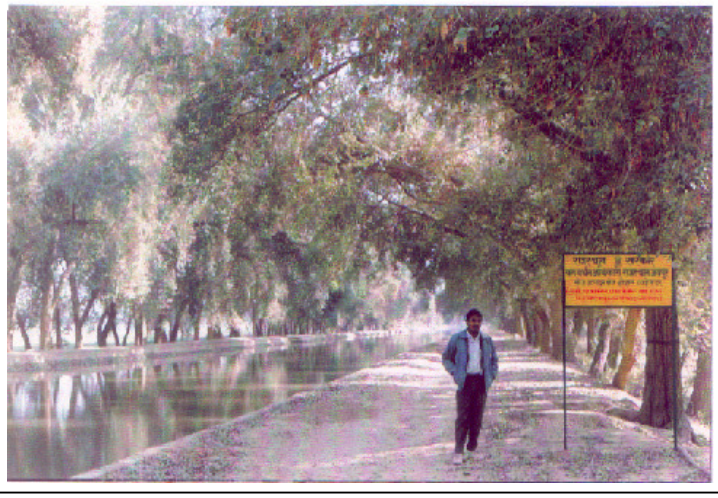
Seed Production area of *Eucalyptus camaldulensis*

The seed stand is situated at 0-7RD, on both sides of Sangeeta Distributory, in the Surat garh range of Ganganagar District in Rajasthan. The plantation was done in 1978. The statistical details indicated that after culling the means of the height, clear bole, girth, diameter and volume have been shifted towards the higher side by 0.74m, 1.86m, 6.16cm, 2.01cm and 0.09m^3 respectively, which was desired. The variability in all the measured traits was reduced after culling.

Seed Production area of *Dalbergia sissoo*

Two stands of *D. sissoo,* one of 20ha. situated at 40-55RD of Navrang Deshar branch (NRD), Hanumangarh under irrigated conditions and another of 10ha. under rainfed conditions at Sanjay Van, Shahpura, Jaipur have been finally selected for conversion into seed production area of *D. sissoo*). These plantations were done in 1969 and 1982 respectively.

Descriptive statistics for height, clear bole, girth, diameter and volume of both seed stands, before and after culling operation, has been calculated and found that the means of total height, girth, clear bole, diameter and volume have been increased due to culling operation in both the seed stands. The mode has either remained the same or increased and decreased for some traits. The decrease in the modal value is due to the removal of large-sized trees with some undesirable traits. The standard deviations for various traits in both the stands have been reduced significantly, indicating for more precision in the measured parameters after culling.



Seed Production area of *Acacia nilotica*

Two seed stands of *A. nilotica*, one of 20 ha., situated under irrigated conditions at 0-22RD of Gharsana minor, Gharsana and another of 15ha. under rainfed conditions at Mandera beed, Deeng, Bharatpur, were selected. The plantation was done in 1978 at Gharsana while at Mandera beed it was natural.

In Gujarat also we have selected two seed stands of *A. nilotica* for conversion into seed production area, 25ha. area at Gushar and another 15ha at Pawagarh. (Table 17). Seed stand of Gushar, Panam Project, Godhra was planted in 1982-84 and at Pawagarh, Godhara, plantation was done in 1978-80.

Statistical analysis of various traits of trees of *A. nilotica* standing in the seed stands at Gharsana and Mandera beed before and after culling showed that the means of total height, bole height, girth and diameter have changed towards betterment with the sharp increase in the clear bole from 1.75m to 2.33m at Gharsana and from 1.90 to 2.56 at Mandera beed. Whereas the mean volume of the trees at Gharsana have not changed due to the removal of the trees having a very large diameters, the volume changed significantly at Mandera beed after culling.

Seed Production area of *Tectona grandis*

A total of 940ha. plantations of teak spread over 15 places in Gujarat State have been surveyed (table 12). Sample plots were laid out in all the surveyed seed stands and analysed statistically. Based on the analysis, six seed stands, scoring maximum points have been selected for conversion into seed production area (tables 13 and 17).

Descriptive statistics of the seed stands of teak, located at six places for conversion into

seed production areas showed that the means of total height, clear bole, girth, diameter and volume have significantly improved after culling. Sample variances as well as the range have been reduced significantly which is of indicative of the fact of involving more homogeneity in the values of the traits under study.

Silvicultural Management of Seed Production Areas

A seed stand must be managed properly in order to yield full production of seeds. The following silvicultural management operations should be undertaken:

- Weeding- The trees in a seed production area have a wide spacing which will benefit the upgrowth of secondary vegetation. During the first years after rouging/thinning weeding should be considered as a major task because they may increase the danger of fire, risk from pests & diseases and impede easy accessibility to the area.

- Moisture conservation- Inter-cultural operations should be done mechanically in between the trees twice a year before onset of monsoon for maximum moisture storage and after monsoon for conservation of the moisture. Suitable SMC works should be carried out depending upon the terrain of the area.

- Fertilisation- Seed production will generally be favoured if fertilisation is applied. Nitrogen usually favours mainly the vegetative growth and not flowering. Nitrogen flowering fertilizer may be applied during crown establishment. NP granulated fertilizer with micronutrients should be applied during flower differentiation. The amount and timing is crucial to obtain the optimal effect as it depends on soil condition and species.

- Thinning and Pruning- The tree crown should be kept open and exposed to light. Small additional thinning and pruning after the main one may be under taken to maintain an open crown and consequently to promote flowering. Prune all the inflorescence regularly after fruits are harvested.

- Flower induction- The operation of inducing flowering by imposing stress on the tree or by applying hormones is usually not applicable to seed stands due to the high cost involved and the relative modest gain obtained from seed stands. Most of the tree species are wind-

pollinated but the setting of beehive is suggested to increase the chances of pollination.

- Isolation zone- Pollination isolation zone of about 50-100m belt may be created all around the seed stand. Buffer zone of entirely different species can also be created.

- Records- Records should, except for general information site (location, climate, soil, age of stand etc.), include all major operations like rouging, thinning, pruning etc. The number of trees in the SPA is an important figure because it is an indication of the genetic base. Seed stand record form is given in Table 8 for keeping complete record of SPAs.

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