CHAPTER-VII

ARID FOREST RESEARCH INSTITUTE, JODHPUR

Established in the year 1988, the Arid Forest Research Institute at Jodhpur has a mandate of developing technologies for afforesting the arid and semi-arid areas. The Institute in the reporting year has undertaken important studies in the field of tree improvement, agroforestry, reclamation of saline lands etc. The following pages give an outline of the research activities and findings thereof in respect of AFRI, Jodhpur during 1995-96.

TREE IMPROVEMENT

Introduction trials

Six species of Acacias were introduced in the year 1991 of which *A. seyal* has given better results. Besides these, provenances for *A. tortilis var. raddiana and A. tortilis* var. *spirocarpa* and for *A. nilotica* var. *tomentosa* and var. *adstringens* were also introduced. *A. tortilis* var. *raddiana* has given better results. Seeds of two species *A. implexa* and *A. sophorae* have been sown for laying out trials this year.

Provenance trials

The trials laid out earlier for *A. nilotica* with 28 provenances (1991) are being maintained regularly and three best provenances Jhabua (3.91 m), Gurgaon (3.20) and Maunath Bhanjan (2.99) have been marked. Similarly the Neem trial with 39 provenances (1992) is also under regular assessment and four best provenances viz. North Bilaspur (4.10 m), Dharwar (4.11 m), Indore (3.86 m) and Sumerpur, Pali (3.85 m) have been selected and a multilocation trial will be laid out during 1997. The other trials of *Tecomella undulata* with 13 provenances (1992), *Pongamia pinnata* with 15 provenances (1994), *Emblica officinalis* (1994), *Hardwickia binata* with 12 provenances (1994) and a progeny trial of *Tecomella undulata* (1994) are progressing well with encouraging results.

Under Neem Network, 25 provenances from 11 countries have been collected during 1995. The seeds were sown in the mother beds and seedlings were pricked out in polythene bags and material is ready for field trials to be laid out at 5 different places during July 1996.

Selection of Seed Stands

To meet the immediate demand of quality seeds, seed stands have been selected after careful screening of good plantations. All these areas are under irrigated plantation comprising of 55 ha. for *A. nilotica*, 56 ha. for *Dalbergia sissoo* and 50 ha. for *E. camaldulensis*.

Selection of candidate plus trees

To establish seed orchards for quality seed production, CPTs have been selected for *A. nilotica* (50) for *Dalbergia sissoo* (56) and for *E. camaldulensis* (74). Seeds have also been collected from individual trees to establish seedling seed orchards.

Tissue Culture

Acacia nilotica

For micropropagation of *Acacia nilotica*, nodal shoot segments were collected from 4 years old tree growing in the experimental field of Forest Genetics and Tree Breeding Division. These segments were cut into 1-2 node pieces. Murashige and Skoog's (MS) medium with different concentrations of auxin and cytokinin were used for bud initiation. 20 per cent bud breaks were observed which started after 10-12 days of inoculation. 8-12 bud breaks were observed in single node after 2-3 subculturing. Different concentrations of Auxin and Cytokinin are being used for establishment of cultures. Explants of different seasons are being collected to study and check the leaching problem.

Tecomella undulata

Explants viz. apical shoot and nodal shoot segments were collected from mature trees of *Tecomella undulata*. Explants of *T. undulata* were cultured in Murashige and Skoog (MS) medium incorporated with auxin (IAA) and cytokinins (Kinetin and BAP).

Ailanthus excelsa

Shoot initiation and multiplication from *in vitro* raised seedling

After complete surface sterilization of viable seeds with 0.1 to 0.2 $HgCl_2$, seeds were germinated on MS medium without hormones. Various explants viz. hypocotyl, epicotyl, cotyledons and cotyledonary nodal segments were used for initiation of shoots. Further, multiplication of shoots from nodal segments show better result than other explants.

Shoot initiation and multiplication from mature tree

Young shoots were collected from field and after removing the larger leaves, the material was cut into small (3-4 cm long) pieces along with single node. After surface sterilization, explant was kept vertically in MS medium with various combinations of P.G.R.. Multiple shoots were observed after 2 weeks. 3-4 shoots were observed in a single explant. These shoots were used for further multiplication.

TESTING AND STORAGE PROTOCOLS FOR IMPORTANT TREE SPECIES OF ARID AND SEMI-ARID REGIONS

A seed testing Laboratory was established at the Institute this year, with the objective to develop seed testing and storage facilities for the tree species of this region. Seed testing procedures are being standardized for various tree species. The results of the various experiments carried out in this respect can be summarised as follows.

Selection of a substratum

Seeds of *Eucalyptus camaldulensis* showed similar trends. However, seeds of *Acacia nilotica, Dalbergia sissoo* and *Prosopis cineraria* showed higher percentage germination in vermiculite than on filter paper or by sand incubation.

Seed collection from candidate plus tree

Medicinal plants at AFRI

Demonstration of planting technique

Water harvesting

Germination studies

Studies on neem seeds showed that seeds from different sources have different viability and percent germination. The viability and germination capacity starts decreasing after the second week of collection and lost completely within two months. However, seeds stored at low temperature ($4\pm1^{o}C$) retained viability up to six months though the germination was very poor (10%) in comparison to seeds stored at ambient temperature ($35\pm3^{o}C$).

Storage studies

Storage of neem seeds at ambient temperature affects moisture content, viability and percentage germination. Spermoplane fungus was more prominent in the seeds stored at room temperature. Studies have shown that initial moisture content has no effect on the long term storability of neem seeds.

Seed health studies

Effect of neem seed kernel powder (NSKP) extractive was tested on neem seed mycoflora. It was clearly observed from the studies that NSKP has fungicidal properties and its water soluble and methanol + water soluble extractives reduce the growth of storage fungi on neem seeds.

Seed viability

It was observed that for the completion of test, *A. nilotica* and *D. sissoo* required 12 hrs. period whereas *A. excelsa* and *P. cineraria* required 16 hrs. and 22hrs respectively. Further work on this aspect is in progress.

BIO-FERTILIZERS

Study on VAM association in neem in arid zone

Status of VAM fungi in nurseries and plantations of neem (*Azadirachta indica*) in and around Jodhpur district was investigated. Variation in % root colonization and number of VAM fungal propagules in rhizosphere of both nursery and plantation samples was observed. It has been observed that mean number of VAM fungal propagules and % root colonization were greater in plantation samples than in nursery samples. A total of ten different VAM fungal species have been isolated and identified.

Studies on VAM association in irrigated plantations and agro-forestry areas

Investigation was made to ascertain the nature of VAM existence in irrigated plantations of IGNP command area and agro-forestry sites in and around Jodhpur district at quarterly intervals. Samples were screened by adopting standard techniques for assessment of percent root colonization and population of VAM fungi.

Screening and selection of suitable VAM strains

An experiment was conducted to examine the effect of inoculation of different VAM fungal strains for their symbiotic response and growth improvement of *Prosopis cineraria* and *P. juliflora* seedlings in nursery condition. Two different VAM fungal strains viz., *Glomus*

fasciculatum (local strain of Rajasthan) and *G. mosseae* (strain obtained from FRI, Dehra Dun) were tested.

SCREENING SPECIES FOR HIGHER PRODUCTION

The experiment was initiated in the month of July 1995 at the experimental field of Forest Ecology and Desert Development Division with an aim to screen different tree species for their utility as commercial crops under irrigated conditions. The experiment was laid in RBD with six tree species namely, *Acacia nilotica, Eucalyptus camaldulensis, Dalbergia sissoo, Albizia lebbeck, Dendrocalamus strictus* (bamboo) and *Tectona grandis* as main treatments and with two sub-main treatments of VAM inoculation and NO VAM inoculation in three replications at a spacing of 3m x 4 m. Seedling planting was done for *A. nilotica, E. camaldulensis, D. sissoo* & *A. lebbeck* while rhizome planting was carried out for *D. strictus*. For *Tectona grandis* (teak) it was stump planting.

SCREENING TREE SPECIES FOR DROUGHT TOLERANCE

A field experiment was initiated in October'95 in the existing four year old plantation, planted uniformly at 3m x 3m spacing with six tree species namely *Azadirachta indica, Acacia nilotica, Acacia planifrons, Albizia lebbeck, Tecomella undulata* and *Prosopis cineraria,* as the main treatment and no mulching and mulching as sub treatments in triplicate, laid in split plot desig . The best performer was *Azadirachta indica* registering 365 cm height, 199 cm crown and 33 cm collar circumference at 57 months age. Whereas, the poorest performer was *Tecomella undulata* having 134 cm height, 91 cm crown and 12.0 cm collar girth. Species in order of decreasing growth are *A. indica* > *A. planifrons* > *A. lebbeck* > *A. nilotica* > *P. cineraria* > *T. undulata.*

REHABILITATION OF DEGRADED ARID SALT LANDS

An experiment to rehabilitate degraded arid salt land was initiated in 1992 at a salt land at Kaparda Village (Jodhpur district) in Luni basin. Experiment was started with two exotic salt bushes *Atriplex lentiformis* and *Atriplex amnicola* and three indigenous species *Salvadora persica, Tamarix aphylla* and *Prosopis juliflora* applying soil management practices such as mixing of gypsum, FYM, drainage, fertilizer application and replacing with good soil. As *Atriplex amnicola* did not perform well and showed nearly 60 % mortality it was removed in the 3rd year.

PREVENTING WATER LOGGING AND SALINITY IN RAJASTHAN

The Indira Gandhi Nahar Pariyojana (IGNP) is an extensive canal system in the Indian Thar Desert. Seepage from the canal has caused water tables in the proximity of the canal to rise. Consequently flow downstream in the canal has been reduced and water logging and salinity problems are being experienced in the proximity of the canal. There has been a reduction in agricultural and pasture production. To develop technology for reclaiming water logged areas, this project was initiated by funding from Australian International Development Assistance Bureau (AIDAB).

The objective of the project is to reduce the waterlogging and salinity resulting from the canal by using appropriate soil and plant management techniques. This will include the establishment of salt resistant species near the canal banks to lower ground water tables.

IRRIGATION WATER MANAGEMENT FOR TREE SPECIES

Water requirement of trees

The experiment was initiated in the month of July 1995 at AFRI experimental field. With frequency of irrigation (IW/CPE) as main treatment and quantity of irrigation as sub treatment in triplicate, the experiment was laid in split plot design. Three plant species taken were (*Dalbergia sissoo, Acacia nilotica* and *Eucalyptus camaldulensis*) planted at a spacing of $3m \times 4m^2$

After two uniform life saving watering the irrigation treatments were initiated in the month of December' 1995. Date of irrigation is being calculated by continuous monitoring of evaporation data from Automatic weather station (IW/CPE ratio). The schedule is being maintained on regular basis.

RAIN WATER MANAGEMENT

Moisture is the major constraint in plantation establishment and growth in arid region. Except in IGNP area most of the plantations are raised under rainfed conditions. Low and erratic rainfall in arid regions results in long periods of severe moisture stress leading to poor establishment and growth of trees. Efficient management of rain water can reduce the length and severity of soil moisture stress causing favourable influence on tree growth. Experiments on different techniques of rain water harvesting and conservation were undertaken to find out the most suitable ones for sandy plains of arid region.

Studies on water harvesting and conservation

A field experiment was initiated in July 1990 at the experimental field of the Institute with different rain water harvesting and conservation treatments such as control, weed clearing (WC), WC and soil working, saucers of 1m diameter, saucers of 1.5 m dia, saucers of 1.5 dia + mulching, bunding in chequer board design and Ridge and furrow structure. During the initial period of 2 years various treatments caused dramatic influence on the growth of plantations. However, these growth differences narrowed down in the subsequent years due to high density of plantation. Therefore, uniform thinning was done and this year trees were thinned to 400 stems/ha. Data collected indicate that various treatments continued to maintain better tree growth than in the control.

Soil surface manipulation for runoff harvesting

About 25 to 40 per cent of the rainfall is liable to be lost through run off which, if prevented, could cause significant improvement in tree growth. Different methods of soil surface manipulation (micro catchment water harvesting structures) were studied for their efficiency in runoff collection, soil moisture storage and tree growth.

Soil moisture storage due to runoff harvesting structures was higher than in the control. The storage was higher in lower layers indicating the possibility of still higher moisture storage in the deeper layers. This was reflected in the moisture stress values in leaf. Leaf water potential of neem was 25 to 40% higher in treated plots than in the control at 14.00 hrs on 15 June 1995.

AGROFORESTRY MODELS

Effect of different crop sequences

The field experiment comprised of 6 treatments of different intercrops (crop sequences) and two tree species, thus making 12 treatment combinations. This year there was long dry spell in August-September, resulting in very poor yield of crops of all the agricultural crops. Mothbean yielded highest grain (194 kg/ha) followed by cluster bean and mung bean. Grain yield of pearl millet could not be harvested. The straw yield was highest from pearl millet (1666 kg/ha) where mungbean - pearlmillet rotation was followed. Crop yield was significantly higher when planted along with *P. cineraria* than *T. undulata.*

Effect of tree density

The field experiment, comprised of three densities (416, 278 and 208 stems per ha) of *Tecomella undulata* and *Prosopis cineraria* planted in combination with Mungbean in 1995, was conducted to find out the effect of tree density on crop yield and tree growth. Grain production declined with increasing tree density. Mungbean yield was 280 kg / ha with khejri density of 208 stem/ha which dropped to 202 kg/ha when khejri density increased to 416 stem/ha. Grain yield was higher in combination with khejri than with rohida.

Agroforestry for maximising fodder and fruit production

Different tree species planted were : *Emblica officinalis, Colophospermum mopane* and *Hardwickia binata* with three replications and six treatments. The agricultural crop harvested in second year was *Cymopsis tetragonoloba* (guar). Highest yield was found under *Colophospermum mopane* (193 kg/ha) followed by *Hardwickia binata* (170 kg/ha). The growth data on 18 months old plants indicate that the tree height was higher in cropped area as compared to no crop area. However, the collar girth was less in cropped area.

MANAGING INDUSTRIAL EFFLUENT FOR TREE ESTABLISHMENT

The experiment was initiated in July 1993 after clearing the existing bushes with the aim to find out the suitability of textile effluent for tree establishment and their performance. The effluent released from textile industries was analyzed for its physical and chemical properties. Seven tree species viz *Acacia nilotica,* (T1), *A. tortilis* (T2), *Albizia lebbeck* (T3), *Azadirachta indica* (T4), *E. camaldulensis* (T5), *Parkinsonia aculeata* (T6)and *Prosopis juliflora* (T7) were planted in randomised block design in three replications and at a spacing of 4 x 4 m^2. Different treatments applied for the irrigation of tree species with the textile effluent were - Irrigation with effluent only (W1), irrigation with effluent diluted with good water in 1:1 ratio (W2), irrigation with effluent treated with gypsum, (W3), Soil treated with gypsum irrigated with effluent (W4) and soil treated with ash irrigated with effluent (W5). Observations on the growth of 28 months old plantation indicate that W5 treatment resulted in the highest growth for all the species viz., 238 cm (T7), 218 cm (T4), 187cm (T5), 186 cm (T6), 147 cm (T2), 127 cm (T1) and 122 cm (T3). The maximum growth was observed in *Prosopis juliflora* followed by *Azadirachta indica* whereas lowest was observed in *Albizia lebbeck.*

NUTRIENT AND MOISTURE DYNAMICS IN ARID ZONE PLANTATIONS

Observations on soil moisture were recorded during October'95 at 25, 50 and 75 cm depths in cruciform pattern at 0.5 m and 3 m distance from the stem in the East- West directions and at 0.5 m distance from the stem in the North - South direction. The data obtained show that with increasing depth the soil moisture generally showed an increasing trend and the per cent moisture nearer the stem being less than that away from the stem in the case of rohida and the reverse being the case in khejri. In the case of khejri, the per cent soil moisture is uniformly the same in both the eastern and western directions whereas, in rohida it is significantly lesser in the eastern side than in the western side of the stem. Not much difference in soil moisture at 0.5m distance was observed in the north south directions.

FOREST ENTOMOLOGY

Pest of Forest Nurseries

The premonsoon survey of different nurseries around Jodhpur revealed that the damage to the seedlings was negligible. With the onset of monsoon insect infestation started and reached its maximum by August to October. Leaf miner *Leucoptera sphenograpta* was found damaging *Dalbergia sissoo* seedlings. Upto 90% infestation was recorded in different nurseries. 30% mortality was observed in *Tecomella undulata* seedlings due to *Patialus tecomella*. White fly infestation was found in almost all the seedlings with maximum infestation in Gulmohar seedlings (60%), *Acacia nilotica* (20%) and *Prosopis cineraria* (12%). Neem seedlings at AFRI, nursery were found severely infested (30%) by a sap sucker. The whitish insect colony had developed on the young stem above the collar region. Both the nymphs and the adults suck the sap from the tender stem and branches resulting in yellowing of leaves and premature leaf fall. The infestation was controlled by prophylactic spray of 36 SL monocrotophos @ 0.02 %. Similarly citrus leaf miner, citrus psyllid and citrus leaf roller were found damaging the citrus seedlings (20-45%) in SFD, nurseries. Upto 65% infestation of *Noorda blitealis* was recorded on *Moringa oleifera* seedlings resulting in defoliation. Spray of monocrotophos @ 0.036% was effective in controlling the pest population. *Catopsilia crocale* was recorded for the first time infesting *Salvadora persica* seedlings.

Infestation in multiplication garden of *Dalbergia sissoo* at AFRI

Lepidopteran defoliator *Plecoptera reflexa* infestation (15-35%) was recorded in the multiplication garden of *Dalbergia sissoo* at AFRI nursery. Other minor pests recorded were *Myllocerus laetivirens, M. dalbergiae, Bagrada picta* and *Epilachna* sp.

Seasonal incidence and control of shisham leaf miner-Leucoptera sphenograpta

The infestation of leaf minor results in premature leaf fall and seedling mortality. The moth is host specific. In arid regions hatching takes place in 4-8 days. Larval period varies from 10-15 days. Pupal stage lasts for 8-12 days. Pupation is prolonged in the month of November-December. Maximum incidence of leaf minor was observed in the month of July when humidity is high.

Seed Entomology

Comparative studies on the life cycle of seed bruchid, *Caryedon gonagra* on seeds of *Acacia nilotica* and *Prosopis cineraria* was carried out. *Bruchidius albizziae*, a major seed pest

of *Albizia* sp. was found infesting seeds of *Acacia nilotica, Prosopis cineraria, P. juliflora, Dalbergia sissoo* and *Tecomella undulata*. These are recorded as new hosts for *Bruchidius albizziae. Caryedon acaciae* infestation (40%) was recorded in the seeds of *Acacia ampliceps*. This is the first record of *C. acaciae* from seeds of *A. ampliceps*.

FOREST PATHOLOGY

Nursery and plantation diseases and their management

Chemical control of leaf curling in neem

Severe incidence of leaf curling was noticed in AFRI nursery. The incidence was noticed between 60-70 percent in poly pots. A combination of Ethion 0.1 ml / ltr + Blitox 1.5 gm + 2ml/1ltr powermin was found effective to control successfully.

Incidence of powdery mildew on forest nurseries

Light to moderate incidence of powdery mildew was noticed on three months old seedlings of neem and one month old seedling of *Cassia siamea* at Chiloda nursery, Gandhinagar (Gujarat). Foliar spray of 0.05 % of kerathane and E.C. 0.05% was recommended to reduce the incidence of disease.

Leaf spot disease of *Ailanthus excelsa*

Leaf spot disease was recorded on *Ailanthus excelsa* seedlings in the nursery. The lower leaves were found more susceptible to the disease. The pathogen has been isolated in PDA and identified as *Alternaria alternata*.

Ganoderma root rot in exotic Acacias

Mortality in *Acacia holocerocea* was observed in an experimental field of the Institute. Two years old young plantation was found attacked by *Ganoderma* root rot disease. Partially affected plants could be revived after giving soil treatment with bavistin (0.1%). The treatment was repeated after one month. The plants are growing well after this treatment.

Bioassay of fungicides against Ganoderma culture

The culture of *Ganoderma* was maintained in PDA. The fungicides namely bavistin and blitox were tested in different concentrations by food poison technique. It was observed that all the treatments are effective but blitox was very effective and it could completely check the growth of mycelium whereas bavistin gave inhibitory effects in all concentrations.

Protection of neem plantation against canker disease

Five years old plantation of neem was found attacked by sun scorching and bark canker problem. About 40-50 % plantation was found susceptible to this disease. The infection starts from collar region and spreads upward. The bole of the trees were painted upto breast height by lime wash, to protect the trees from sun scorching.

Chemical control of *Fusarium* root rot in neem

Severe incidence of *Fusarium* root rot disease (30-40%) was observed in neem. Soil drenching of bavistin 0.1% was applied in one month intervals.

BIOPESTICIDES

Study on the antagonistic effect of neem seed kernel powder (NSKP)

The antagonistic effect of Neem Seed Kernel Powder (NSKP) with special reference to acetone and methanol extracts on growth rate and nutritional indices such as CI, AD, ECD and ECI by the babul defoliator, *Taragama siva* were evaluated.

Study on the impact on reproductive potential of *T. siva* fed on NSKP extract treated leaves of *P. juliflora, P. cineraria* and *A. senegal*

The reproductive ability of moths emerging from larvae fed on leaves treated with methanol extracts greatly reduced as compared to acetone and control. Among the extract tested, *P. cineraria* leaves treated with 0.5% level greatly inhibited egg output than others. The fecundity of *T. siva* showed marked variation in various host plants and high fecundity was observed in control followed by *A. senegal* and *P. cineraria.*

Small scale evaluation of neem seed oil against the babul whitefly *Acaudaleyrodes rachipora*

An experiment was conducted to study the efficacy of neem seed oil and some conventional insecticides against the babul whitefly *Acadaleyrodes rachipora* on *Acacia senegal.* The results revealed that neem seed oil at 0.5, 0.3 and even at 0.1% concentrations were very active and suppressed the development of the whitefly significantly while monocrotophos and endosulfan were not effective to suppress this whitefly.

NON-WOOD FOREST PRODUCTS

Oil seeds

Determination of fatty oil content and oil quality of neem seeds from different agro-climatic zones of Rajasthan

Fatty oil contents of neem seeds collected from all the nine agro-climatic zones (ACZ) of Rajasthan have been determined. Seeds from Banswara region (ACZ-IVB) were found to have highest percentage of fatty oil where as the lowest oil content was found in seeds from Jaisalmer area (ACZ-1A).

Physico-chemical values (specific gravity, refractive index, acid value, etc.) of oil samples extracted from seeds of different ACZs were also determined. All these quality determining characters of oils showed variations with different agro-climatic zones.

Fatty oil content of neem seeds of different geographical origin

Neem seeds of Indian and International provenances procured under International Neem Network were studied from the angle of seed index, seed/kernel ratio and fatty oil content.

Among the five Indian provenances, seeds from Hyderabad (28.60 g) and among the international provenances, those from Nepal (Geta) (19.67 g) were found to have highest seed index. The seed to kernel ratio varies from 1.542 to 2.252 among all the provenances. The fatty oil content, among the five samples of Indian provenances, was highest (40.2 %) in seeds from Hyderabad whereas among the international provenances the seeds from Bangladesh were found to have highest (48.6 %) fatty oil content.

Screening of Arid Zone Flora for Fatty oils

To augment the production of fatty oils from the forest oil seeds further, it was envisaged to screen the flora of arid and semi-arid areas of Rajasthan and Gujarat. In continuation of the work of screening the forest seeds, the seeds of *Acacia nilotica* ssp. *cupressiformis* and *Acacia senegal* were extracted with petroleum ether as solvent. The oil content in these seeds was determined to be 5% and 2% respectively. Determination of the physico-chemical constants of the oils is in progress.

Determination of Azadirachtin Content in Neem Seeds

Method was standardised for estimating Azadirachtin content in neem seed kernels with the help of High Performance Liquid Chromatography (HPLC) system. Analysis was carried out by using Novapack C-18 stainless steel column, solvent system acetonitrile-water and UV detection at 214 nm. For quantitative determination of Azadirachtin in unknown samples, its peak in HPLC chromatogram was compared with that of known standard. Extraction of the seed kernel was carried out with Petroleum ether and then with Methanol followed by partition with Dichloromethane of the latter for carrying out the analysis.

Proteins

Different plant parts viz. seeds, leaves and branches are proposed to be screened for their crude protein contents. Preliminary results on studies on the seeds of *Azadirachta indica* obtained from seven international provenances of the Neem Network countries showed that seeds from Laos contain the maximum and those from Bangladesh contain the minimum amount of crude protien. Further studies are in progress.

GROWTH STUDIES IN THE IRRIGATED PLANTATIONS OF IGNP AREA

To understand the growth pattern and yield of different plantations in IGNP commanded areas, the Institute initiated systematic studies this year. Volume data was collected from 40 felled trees of *Acacia tortilis* and equations were developed for volume under bark and overbark.

Permanent sample plots

Study on the two most important species planted in the area viz. *Dalbergia sissoo* and *Eucalyptus camaldulensis* was taken up under the World Bank aided FREE project. Eight sample plots of *D. sissoo* and seven of *E. camaldulensis* have been so far laid out at different locations in the area. Care has been taken to include plantations of different ages and spacings in the study. Five sample trees have been felled from the surround of each plot and volume data has been collected. Laying out of new sample plots and annual measurements in each plot will continue upto March 1998.

GROWTH AND BIOMASS STUDIES ON NEEM

This project was started in the last year. Six sample plots were laid out in Gujarat and 25 trees were marked for felling. This year the marked trees were felled and volume and biomass data have been collected. The plots were remeasured. The collected data is being analysed and new sample plots will be laid out in the next year.

LOPPING STUDIES ON THE FODDER SPECIES OF ARID ZONE

The objective of this project is to find out the effect of different intensities of lopping on the height, dbh, crown parameters and fodder yield of important arid zone fodder tree species. Work was initiated on *Prosopis cineraria* and *Ailanthus excelsa* towards this objective. Plots have been laid out in RBD with four lopping intensities (nil, slight, moderate and heavy) in three replications. Trees have been enumerated and lopped in summer and winter of 1995-96 in both the plots.

GROWTH MODELLING FOR ARID ZONE TREE SPECIES

Mathematical growth models developed for *Eucalyptus camaldulensis, Acacia nilotica* and *Prosopis juliflora* showed that in the case of *E. camaldulensis* the height growth at early stage is faster when stand density is high but the spacing has more pronounced effect on diameter growth. The result also indicated that a plantation spacing of 3m x 3m may be taken as appropriate for the production of merchantable timber. In the case of *A. nilotica*, it was found that plantation spacing has not much effect on height growth and the growth in height and dbh is rapid up to 5-10 years of age. In the case of *P. juliflora*, it was observed that there is large variation in the diameter growth if plantations are under better soil moisture regime.

PHENOLOGICAL STUDIES ON NEEM

Phenological data collected from 12 different locations distributed in six agro-ecological regions of the country during April 1993-December 1994 was analysed. It is seen that most of the trees are in heavy leafing during May-November. Leaf shedding starts by November and the trees are back in full leafing by April. Peak flowering period was found to be during March-May. The fruiting period for arid and semi-arid regions is May-June whereas that for the sub-humid regions is between April and July. Best seed collection month for arid regions was found to be June. For the semi-arid and sub-humid regions it is in June and July. Based on the observations from this pilot study, proposal for a more elaborate study involving 13 agro-ecological regions of the country where neem is found to grow has been submitted to the International Neem Network.

MARKET TRENDS

Quarterly market prices of selected timber and fuel-wood species and of bamboo were collected from the Jaipur and Ahmedabad markets for publication of Trade Bulletin on timber and bamboo.

FOREST STATISTICS

Forest statistics are being collected from different States for the 1984-94 period.

NABARD PROJECT

The Institute has taken up NABARD assisted 5 year Agro-Forestry project. The main objective of the project is to develop suitable Agri-Silvi, Silvi-horti and Silvi-pastoral models for Arid areas of Rajasthan. Emphasis is to be given on increasing productivity through introduction of integrated package of watershed management technology and design of land use management plan for the selected areas.

Three Microwatersheds namely Jaleli Ahincha, Sangariya and Kudi Bhagtasni have been identified. Socio-Economic survey has been completed for all the villages. Selection of areas was done on the criteria of proximity, approachability and facilities available for implementation of the project. Areas are also representative to arid tracts of Rajasthan. The areas of the microwatersheds are as follows :

i)	Jaleli Ahincha Microwatershed	1096 Ha.
ii)	Sangariya Microwatershed	1289 Ha.
iii)	Kudi Bhagatasini Microwatershed	1044 Ha.

EXTENSION

34 Forest officials, 19 NGOs and 180 farmers were imparted demonstration cum training on use of biofertilizers particularly "VAM inoculum production and inoculation techniques"

Technology Transfer

* To disseminate information about up-to-date forestry technology, training cum demonstration programmes have been organised. During the year 34 forest officials, 11 NGOs and 480 farmers have been imparted training in seed technology, nursery raising, tree planting, soil moisture conservation practices, plantation management etc.
* During monsoon season 1000 farmers were given an on the spot demonstration on the technical know-how of tree planting in farmers' field. More than 7500 seedlings of species like *Azadirachta indica, Acacia nilotica, Prosopis cineraria, D. sissoo, A. lebbeck, Eucalyptus* and fruit plants of *Zizyphus nummularia, Citrus, Pomegranate* and guava have been distributed in villages selected under UNDP.
* Audio-video shows were organised in UNDP villages to create an awareness and motivate rural folk for tree planting.
* Short notes/leaflets/hand outs on *Azadirachta indica, Acacia nilotica, Prosopis cineraria, D. sissoo, A. lebbeck, Zizyphus nummularia, citrus,* etc. have been prepared and distributed among farmers.