CHAPTER VII

ARID FOREST RESEARCH INSTITUTE, JODHPUR

Arid Forest Research Institute (AFRI), Jodhpur, was established in the year 1988 with the objective to develop technology for desert afforestation and reclamation of arid and semi-arid areas. The main emphasis of research work would be on evolving species and provenances of high yielding fodder and fuel, on developing agroforestry and agri-silvi-pasture models suitable for arid and semi arid regions, on developing technology for afforestation of sand dunes, saline and alkaline lands, etc., study of the irrigated plantations in Indira Gandhi Canal Project area and on evolving package of practices for maximising production on sustainable basis. The institute has a mandate to meet the forestry research needs of States of Rajasthan, Gujarat and Dadra and Nagar Haveli.

Considering the prevailing harsh environmental and edaphic conditions of arid region, the work of afforestation on massive scale has assumed the most important place out of all the desert development activities. The Institute has undertaken research on various aspects of forestry to develop technological packages for maximising forest growth on principles of sustainability. The institute has made significant strides in the fields of tree improvement, water management, land reclamation, silviculture, biofertilizers, agroforestry, social forestry and extension technology.

TREE IMPROVEMENT

In order to develop plant types with higher potential and at the same time maintaining the traits of resistance to drought, heat, salinity, insect pests and diseases, research on various aspects of tree improvement *viz.* provenance trial, tissue culture, etc. has been taken up.

Provenance trials

Provenance trials have been laid successfully for *Acacia nilotica* from 28 provenances (1991), exotic Acacias of 15 provenances (1991), *Tecomella undulata* of 13 provenances (1992), *Azadirachta indica* of 39 provenances (1992) and *Azadirachta indica* var. *siamensis* of 5 provenances from Thailand (1993). Progeny trial of *Tecomella*

undulata has also been laid (1993). Results of all these trials are very encouraging.

Following provenance trials of multipurpose tree species have been established during the current year:

Pongamia pinnata (Karanj)

Pongamia pinnata is an oil-yielding species, which is found to grow well under arid conditions. Provenance trial of *Pongamia pinnata* was taken up in 1994. Seeds were collected from 15 provenances from different parts of the country. Seedlings raised in nursery were planted in the experimental field, with a spacing of 3m x 3m. The provenance from Jodhpur has attained maximum average height of 43.30 cm followed by Danta (Gujarat) with 32.0 cm in six months.

Emblica officinalis (Aonla)

Emblica officinalis is valued for its fruits, which are the richest known source of Vitamin C. Provenance trial of this species using seedlings from different regions of the country was initiated in 1994 in the experimental fields of the Institute. Maximum height was attained by Rajpipla (Gujarat) provenance (87 cm), followed by Dausa (Rajasthan) provenance(75 cm) in six months.

Hardwickia binata (Anjan)

Hardwickia binata is an important fodder species of arid and semi arid regions. To tap the genetic potential of this species in terms of fodder yield and quality, provenance trial of *Hardwickia binata* has been initiated at the Institute.

The trial has been laid with 12 seed sources from the States of Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh and Tamil Nadu.

Introduction of exotic Acacias

Six species of Australian Acacias namely *Acacia holosericea, A. ampliceps, A. coleims, A. adsurgens, A. bivenosa* and *A. victoriae* were introduced at Jodhpur. Twelve months after planting, *A. ampliceps* was found to be the best suited for locality followed by *A. coleims*.

Exchange of seeds under International Neem Improvement Network Programme

Neem seeds have been collected and despatched under International Neem Net work Programme to CIRAD-Foret for distribution to collaborator countries outside Asia. Seeds have also been despatched to neighbouring countries viz., Sri Lanka, Pakistan, Nepal, Thailand and Bangladesh for International Neem Provenance Trials.

Neem seeds received from other countries as detailed below, were tested for

their germination and seedling raised in nursery, for laying provenance trial to be taken up during 1995 rains.

Details of Neem seeds received from other countries for provenance trial

S. No.	Provenance	Country	Date of collection	Date of despatch	Date of receipt at AFRI	Date of sowing	Germination %
1.	Ban Bun Thap Pran	Thailand	31 March-1 April'94	--	9 May'94	10 May'94	4.5
2.	Ban Bo, Kalasin	Thailand	4-6 April'94	--	9 May'94	10 May'94	2.5
3.	Tapaya, Prachenburi	Thailand	1-3 April'94	--	9 May'94	10 May'94	9.0
4.	Phaisalec, Nakon Sawan	Thailand	April'94	--	9 May'94	10 May'94	6.5
5.	Thazi	Myanmar	17 Juna'94	--	3 Aug.'94	4 Aug.'94	20.0
6.	Moniywa	Myanmar	15 June'94	--	3 Aug.'94	4 Aug.'94	21.5
7.	Yezin, Pyinmana	Myanmar	11 June'94	--	3 Aug.'94	4 Aug.'94	18.0
8.	Magway	Myanmar	13 June'94	--	3 Aug.'94	4 Aug.'94	16.0
9.	Mombo	Tanzania	--	30 Aug.-'94	15 Sep.'94	16 Sep'94	7.5
10.	Bandia	Senegal	--	23 Aug.-	15 Sep.'94	16 Sep'94	13.3

TISSUE CULTURE

Research continued on hardening aspect of micro-propagation protocols developed for *Azadirachta indica* and *Anogeissus pendula* during the last year. Using different types of containers under varying conditions, it was found that glass containers with 60-70% RH at 3000 lux light intensity and 25 ± 2^0 gave optimum survival of plantlets of *Azadirachta indica* and *Anogeissus pendula.*

During the current year *Tecomella undulata* and *Dendrocalamus strictus* were taken for micropropagation work. Candidate plus trees of *Tecomella undulata* were selected and marked. Shoots were harvested from these plants. Nodal shoot segments (2.0-2.5 cm long and 0 3-0.5 cm thick) were used for shoot initiation and shoot multiplication studies. The explants were put vertically, horizontally and inclined at an angle of 45-60^0 on MS-full strength medium containing different auxins (Indol acetic acid, Indol butyric acid, Naphthalene acetic acid) at various concentrations and optimum conditions were evaluated for rapid multiple shoot induction from the explant. It was observed that vertical position of explant, 2 to 5 mg/l of BAP and 0.1

mg/l IAA gave optimum shoot initiation (3-5 shoots/explant). For shoot multiplication BAP 1.0 mg/l and IAA 0.1 mg/l was regularly employed, which gave 5 to 8 shoots per segment.

In *Dendrocalamus strictus* nodal shoot segment was used as explant source. Optimum shoot production (5-10 shoots per explant) was observed under full strength MS, spiked with IAA + NAA 0.1 mg/l and BAP 2.5 mg/l.

In-vitro raised seedlings were used for callus line production of plantlets. Leaf, leaf sheath, root, node, internode and basal region of root were employed for callus growth. Optimum callusing was observed from basal nodal segment.

Micro-shoots from both the species were rooted in 1/2 MS media with varying conditions and growth promoting hormones. *Tecomella undulata* gave 50-60% rooting response within 15 days of incubation period against the normal reported time of 30-60 days. In *Dendrocalamus strictus*, callus line gave 80-90 per cent rooting response under tested conditions. Experiments are underway to ameliorate the factors responsible for lower response.

NURSERY TECHNOLOGY

An experiment was conducted to determine the suitable pre-treatments and planting containers for better seedling growth of tree species: *Acacia nilotica, A. senegal* and *Albizia lebbeck.*

The results revealed that *A. nilotica* seeds germinate better after acid treatment for 30 minutes and hot water treatment for 2 hours. *A. lebbeck* showed improved germination when seeds were soaked in water for more than 12 hrs upto 24 hrs. Very high germination was noticed in *A. senegal* seeds soaked in water for 12 hrs.

In the experiment on different types of planting containers, viz., polythene bags, glass containers and earthen pots, it was found that all the three species performed better in polythene bags in comparison to glass containers and earthen pots as evidenced from seedling height measurement.

Effect on seedling height of different arid zone tree species grown in different planting containers

Containers	Height (cm)		
	Acacia nilotica	*A. senegal*	*Albizia lebbeck*
Plastic glass	50.1	21.9	25.0
Earthern pots	39.6	22.3	33.7
Polybags	56.4	28.3	45.5

The shoot dry weights of *A. nilotica* and *A. senegal* seedlings in polythene bags were found to be higher than those in other containers. However, the shoot dry weight of *A. lebbeck* seedlings was maximum in earthen pots. Similarly, the root dry weight of *A. nilotica* seedlings in polythene bags was found to be more in comparison to other containers used, whereas the root dry weight of *A. senegal* and *A. lebbeck* were maximum in earthen pots.

Effect on shoot dry weight and root dry weight of different arid zone tree species grown in different planting containers

Containers	Shoot & root dry weight (gm)					
	Acacia nilotica		*A. senegal*		*Albizia lebbeck*	
	Shoot wt	Root wt	Shoot wt	Root wt	Shoot wt	Root wt
Plastic glass	0.540	0.025	0.699	0.465	0.520	0.386
Earthen pots	1.108	0.079	0.696	0.484	0.790	3.681
Polybags	3.323	0.550	3.770	0.062	0.640	1.952

BIOFERTILIZERS

VAM association plays a significant role in nutrient supply, particularly phosphorus. Studies on VAM fungal association and their frequency of occurrence in rhizosphere soils under the root zone of *Prosopis cineraria* and *P. juliflora* plantations were undertaken. A total of 10 different fungal species of the genera *Glomus* and *Gigaspora* were identified from the rhizosphere of both the tree species. Among the different species of the genus *Glomus*, *G. fasciculatum* was found to be the most predominant fungus and occurred in the rhizosphere of both the tree species screened which was followed by *G. macrocarpum*, *G. fulvus* and *G. intraradices*.

Selection of suitable host plants for VAM inoculum multiplication

Host plants such as *Cenchrus* spp, bajra, maize, onion, sorghum and wheat were tested as a cover crop for the pure culture and mass inoculum production of VAM fungi. The results of the experiment revealed that *Cenchrus ciliaris*, *C. setigerus*, maize and sorghum are suitable cover crops for the mass multiplication of VAM inoculum.

Percentage colonization and the number of VAM propagules in different host plants (Age of the plants: 60 days)

Host plants	% colonization	No. of spores/ 50 ml soil
Cenchrus ciliaris	82	508
C. setigerus	87	486
Maize	94	598
Onion	56	324
Pearlmillet	48	321
Sorghum	58	319
Wheat	40	304

Selection of suitable soil substrates for the production of VAM inoculum

Experiment conducted to find out the suitable soil substrates for the production of VAM inoculum revealed that the soil type of soil + sand (1:1 ratio) is more suitable for VAM inoculum production.

Effect of different substrates on percent colonization, spore number and inoculum potential of VAM fungi and shoot and root dry weight of maize seedlings.

Subtract	Shoot dry weight (g)	Root dry weight (g)	Percentage colonization	No. of spore/50 ml soil
Soil	5.2	3.0	52	329
Soil + Sand (1:1)	9.8	5.0	93	615
Soil + Clay (1:1)	4.4	2.5	40	225
Soil + Clay + Sand (1:1:1)	4.6	2.6	46	298

VAM inoculation for the improvement of growth of different arid zone tree species

An experiment carried out to study the effect of VAM fungal inoculation on the growth of important arid zone tree species at the nursery condition revealed that all the VAM inoculated seedlings showed better growth and shoot and root biomass when compared to uninoculated control seedlings. Among the inoculated seedlings, the shoot dry weight was maximum in *Prosopis cineraria* followed by *Acacia senegal*, *A. nilotica* and *A. tortilis*. The study revealed that VAM fungi significantly increased the plant growth and extensive colonization of roots.

Effect of VAM fungal inoculation on important arid zone tree species (Age of the plants: 90 days)

	Shoot Length (cm)	Shoot dry wt. (g)	Root dry wt. (g)	% Infection	Shoot length (cm)	Shoot dry wt (g)	Root dry wt. (g)	% Infection
Acacia nilotica	3.5	1.89	1.05	27	10.2	3.01	1.52	69
A. senegal	4.1	2.84	1.34	34	11.8	4.65	2.04	74

A. tortilis	3.2	1.48	0.98	29	8.6	2.10	1.26	61
Prosopis cineraria	4.7	2.54	1.56	41	12.7	4.43	2.48	83

MOISTURE MANAGEMENT

Studies have been carried out on different water harvesting and conservation practices and soil working techniques for efficient utilization of rain water in tree establishment and growth.

Rain water harvesting and conservation

Various techniques of rain water harvesting and conservation were studied for their efficacy in improving and maintaining better soil moisture regime and enhancing tree growth. After four and half years of planting, *Azadirachta indica* and *Prosopis cineraria* attained tree heights of 418 cm and 234 cm and collar girths of 39.0 and 17.2 cm due to ridge and furrow structures as compared to their heights of 306 cm and 187 cm and girths of 21.1 cm and 14.4 cm in control. Saucers of 1.5 m diameter covered with mulching was found to be the best treatment for *Tecomella undulata,* which registered a height of 264 cm as compared to 181 cm in control. Weeding increased the tree height by 33% in *Azadirachta indica,* 20% in *Tecomella undulata* and 10% in *Prosopis cineraria,* thus focusing the necessity of weed removal in arid zone plantations.

Growth of four and half year old trees due to different water management treatments.(cm)

Treatments	*Azadirachta indica*		*Prosopis cineraria*		*Tecomella undulata*	
	Height	Girth	Height	Girth	Height	Girth
T_1	306	21.1	187	14.4	181	15.9
T2	406	30.7	203	16.3	222	18.0
T_3	378	27.5	151	14.4	221	18.2
T4	414	31.1	214	16.7	223	17.9
T_5	401	28.8	217	16.1	239	19.4
T_6	428	33.3	201	16.3	264	18.4
T_7	396	29.0	193	14.8	203	17.0
T_8	418	39.0	234	17.2	253	17.6

T_1: Control, T_2: Weed clearing (W.C.), T_3: W.C. and soil working, T_4: W.C. & saucers of 1m dia, T_5: W.C. & saucers (1.5m dia), T_6: W.C. & saucers (1.5m dia)+mulching, T_7: Bunding in checker board design, T_8: Inter row slopes (20%)

Soil working techniques

Experiment with different soil working techniques i.e. ordinary pits, saucer pits, ring pits, trench cum mound, trench and mound and deep ploughing, was carried out with tree species of *Albizia lebbeck, Azadirachta indica* and *Prosopis cineraria* as the test plants. It was found that *A. lebbeck* attained 354 cm height and 26 cm collar girth in ring pits, as compared to 115 cm height and 9 cm girth in control. *A. indica* due to ring pit technique was 367 cm tall and 28 cm thick, as compared to 188 cm tall and 14.5 cm thick in control. For *Prosopis cineraria* ring pits as well as saucer pits were equally effective, where trees were 199 cm and 201 cm tall respectively, as compared to 55 cm in control.

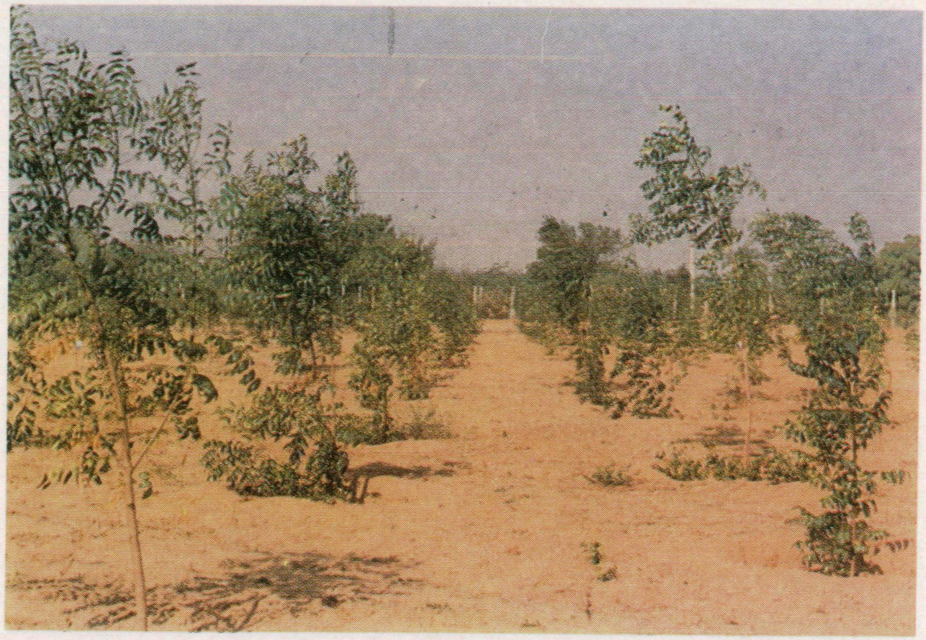
Influence of various soil working techniques on height and girth (cm) of 30 month old trees.

Treatments	*Albizia lebbeck*		*Azadirachta indica*		*Prosopis cineraria*	
	Height	Girth	Height	Girth	Height	Girth
Ordinary pits	115	9.0	188	14.5	55	9.7
Saucer pits	309	22.8	367	24.7	201	14.8
Ring pits	354	26.16	367	28.1	199	15.2
Trench cum mound	192	20.9	216	13.9	129	12.3
Trench and mound	334	22.7	365	26.3	183	15.3
Deep planting + pitting	258	19	303	23.0	99	11.6

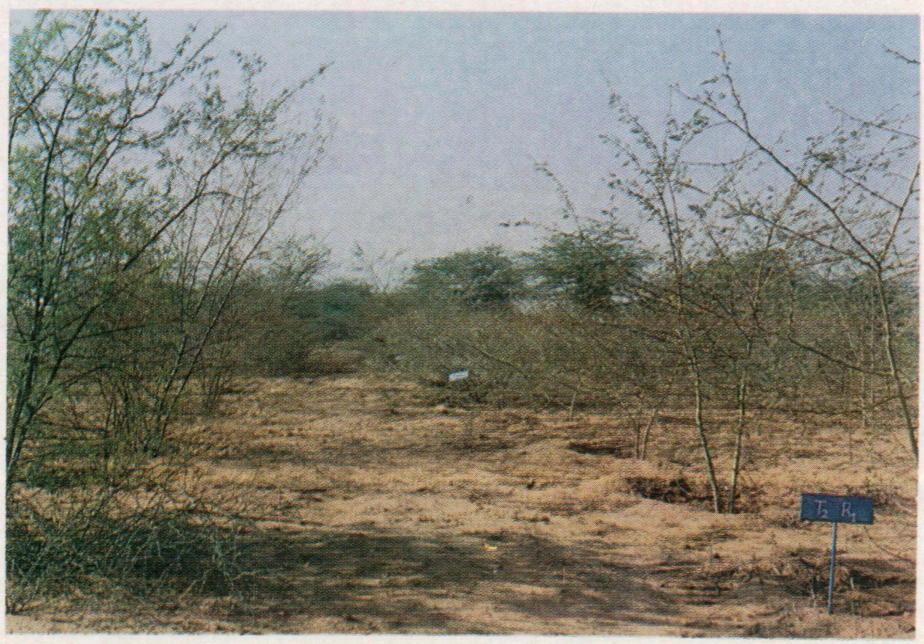
Moisture storage improvement

An experiment was laid out using water absorbing organic polymer STOCKOSORB (400 K) for improving moisture holding capacity for better growth of seedlings in forest nurseries in arid zone and also to standardise its optimum dose.

Five doses of Stockosorb (400 K) were used - 0.5, 1.0, 1.5, 2.0, and 2.5 grams per kg soil, which were designated as D_1, D_2, D_3, D_4 and D_5 respectively. A control D_0 was also maintained. Five levels of irrigation were adopted at daily, once in two, four, seven and fourteen days interval and designated I_1, I_2, I_3, I_4 and I_5 respectively. Each treatment was replicated thrice. Height was recorded on monthly basis. The two month mean height growth data of *Albizia lebbeck* seedlings are given in following Table:



Provenance trials of Neem



Provenance trials of Acacias

Development of agro-forestry models

Energy plantation of *Eucalyptus camaldulensis* in IGNP area

Effect of Stockosorb on height of *Albizia lebbeck.*

Doses--> Irrigation(I)	D_0 Control	D_1 (0.5 g/kg)	D_2 (1.0 g/kg)	D_3 (1.5 g/kg)	D_4 (2.0 g/kg)	D_5 (2.5 g/kg)
	Two month mean height cm					
I_1 (Daily)	23.3	22.2	25.3	24.8	24.4	25.2
I_2 (2 Days)	23.8	25.4	31.5	23.9	25.9	26.1
I_3 (4 Days)	29.3	30.0	31.9	28.7	29.3	27.9
I_4 (7 Days)	26.1	27.9	26.7	26.8	28.2	27.9
I_5 (14 Days)	25.5	26.0	27.0	27.5	26.3	27.0

Preliminary results show that organic polymer like Stockosorb (400 K) has potential for utilization in raising good nursery stock of forest species in arid and semi - arid regions with limited water supply.

AGROFORESTRY MODELS

Studies have been undertaken with varying tree density and different tree-agricultural crop combinations to develop suitable agroforestry models.

Tree-crop combinations

The study involved tree species *Prosopis cineraria* and *Tecomella undulata* and agricultural crops mungbean, mothbean, clusterbean and pearlmilllet. Growing of legume crops did not adversely affect the tree growth. There was slight reduction in the growth of *Prosopis cineraria,* when raised with pearlmillet. Growth of *T. undulata* also remained unaffected, when raised with different agricultural crops.

Tree height (cm) in different agroforestry models

	Khejri model			Rohida model		
Treatments	Height	Girth	Crown	Height	Girth	Crown
No Crop	260	20.1	189	257	20.1	191

Mungbean- M	252	20.2	169	228	19.4	184
Mothbean- Mo	248	19.9	142	245	21.8	199
Clusterbean- C	283	23.4	194	258	23.1	206
Pearlmillet- P	226	18.8	186	247	21.6	191
Mungbean- M	249	21.0	175	261	23.0	188

The maximum grain yield was recorded by mungbean followed by cluster bean. Additional income over the tree stand was maximum (Rs. 5652/ha) with khejri - mungbean model.

Crop production under different agroforestry models (kg/ha)

	Khejri Model			Rohida Model		
Treatments	Grain	Straw	Total	Grain	Straw	Total
No Crop	-	-	-	-	-	-
Moong - Moong	335	1064	1399	312	671	983
Moth - Moth	52	1620	1672	47	1655	1702
Guar - Guar	109	1111	1220	111	856	967
Pearlmillet - Pearlmillet	-	1979	1979	-	1753	1753
Moong - Pearlmillet	376	764	1140	347	810	1157

* Yield of first column crop.

Additional income (Rs/ha) over tree stand in different agroforestry models

Treatments	Khejri Model			Rohida Model		
	Grain	Straw	Total	Grain	Straw	Total
No Crop	-	-	-	-	-	-
Moong - Moong	4355	1064	5319	4056	671	4727
Moth - Moth	520	1620	2140	470	1655	2125
Guar - Guar	545	1111	1656	555	856	1411
Pearlmillet - Pearlmillet	-	1979	1979	-	1753	1753
Moong - Pearlmillet	4888	764	5652	4511	810	5321

Prevailing rates (Rs/kg)	Moongbean	Mothbean	Clusterbean	Pearlmillet
Grain	13.00	10	5	6
Straw	1.00	1	1	1

Tree Density in Agroforestry Systems

The best growth of khejri as well as rohida was observed with a tree density of 400 trees per ha under both uncropped and cropped conditions. With increasing density, decline in growth was more in khejri than rohida. Grain and straw production of cluster bean were also the highest with tree density of 416 per ha, being 422 kg/ha and 2250 kg/ha, respectively as compared to only 233 and 1056 kg/ha with the Khejri tree density of 1666 per ha.

Influence of density on tree growth in different agroforestry models

Density per ha	Height (cm)		Girth (cm)	
	Non cropped	Cropped	Non Cropped	Cropped
Khejri Model				
1666	153	198	13.9	14.6
833	240	233	18.4	17.6
416	292	299	21.2	23.8
Rohida Model				
1666	144	189	11.1	14.3
833	222	236	17.7	17.3
416	238	233	19.2	17.7

Influence of different agroforestry models on grain and straw production of clusterbean (Kg/ha)

Tree density	Khejri Model		Rohida Model	
	Grain	Straw	Grain	Straw
1666	233	1067	206	1020
833	332	1990	267	1671
416	422	2250	420	2215

Agroforestry models for fodder and fruit production

Three tree species viz *Emblica officinalis, Colophospermum mopane* and *Hardwickia binnata* were planted in July, 1994. The agricultural crop was *Vigna radiata.* The initial plant height was recorded. The crop was harvested and the yield of mung bean was highest with *Emblica officinalis.*

Initial height (cm) of tree species

	Tree species		
	Emblica officinalis	*Colophospermum mopane*	*Hardwickia binnata*
Mung bean	97.8	38.3	28.0
No Crop	95.9	32.8	23.2

REHABILITATION OF DEGRADED ARID SALT LANDS

Two exotic salt bush species (*Atriplex lentiformis* and *Atriplex amnicola*) and some naturally occurring salt loving species viz. *Salvadora persica, Tamarix aphylla* and *Prosopis juliflora* were studied applying soil management practices namely mixing of gypsum, farm yard manure, drainage, fertilizer application and replacing with good soil. Performance of *A. lentiformis* was best and it responded to various treatments. T_4 treatment (with gypsum, drainage, urea and Zn) showed best results with average height of 116 cm and crown diameter of 137 cm as compared to 82 cm and 107 cm in the control.

A. amnicola in T_4 treatment was 74 cm tall having 69 cm crown diameter, as compared to 59 cm height and 43 cm crown diameter in control. When no watering was done, survival was 33% in the control, while it was 61% in T_4.

Among indigenous species, performance of *P. juliflora* was the best and in the T_3 treatment (replacement with good soil + FYM) it attained average height and crown diameter of 114 and 267 cm respectively, as compared to 73 and 179 cm in control.

Salvadora persica attained a height of 93 cm and a crown diameter of 120 cm. T_3 (replacement with good soil + FYM) came out to be the best treatment with average height of 93 cm and crown diameter of 120 cm, as compared to 88 cm height and 99 cm crown diameter in control (T_5). The survival percentage was 100% for T_4 and 93% in control.

MANAGING INDUSTRIAL EFFLUENT FOR TREE ESTABLISHMENT

The experiment was initiated in July 1993 for assessing the suitability of industrial waste water for tree establishment and their performance. The different treatments applied for the management were : W1 - Watering with effluent water only, W2 - Watering with effluent + good water in 1:1 ratio, W3 - Watering with

effluent water treated with Gypsum, W4 - Watering with effluent water + soil treated with gypsum, and W5 - Watering with effluent water + ash treated soil. The tree species tried were *Acacia nilotica* (T1), *Acacia tortilis* (T2), *Albizia lebbeck* (T3), *Azadirachta indica* (T4), *Eucalyptus camaldulensis* (T5), *Parkinsonia aculeata* (T6) and *Prosopis juliflora* (T7).

Observations taken one year after plantation show that the performance of treatment (ash treated soil irrigated with effluent water) was better as compared to other treatments.

Tree height 1 year after plantation due to different treatments.

Treat-ments	Tree species						
	T1	T2	T3	T4	T5	T6	T7
W1	67	70	34	69	55	56	109
W2	73	70	76	72	60	41	123
W3	81	74	90	70	59	72	112
W4	64	76	50	65	64	66	131
W5	76	87	66	65	90	103	133

PEST AND DISEASE MANAGEMENT

Following forestry insects and non-insect pests were studied:-

Insect Pests of Neem

Myllocerus laetivirens Marsh: This weevil is becoming an important defoliator of neem seedlings in arid regions. The adults initially make a small hole in the leaf and then eat the entire leaf surface. Monocrotophos @ 0.03% was found to be effective in controlling this pest.

Laspeyresia koenigana Fabr. 70% infestation was recorded in nursery. The moth lay eggs on the superimposed shoots. The caterpillars feed voraciously on the leaf content and before pupating recreate a web like structure folding the leaf and pupates inside. The adult emerges out in 10-12 days. The pest is effectively controlled by spraying monocrotophos @ 0.03 %.

Insect pests of Acacias

The survey of insect pest of Acacias provenance trial at AFRI revealed that *Odontotermes* sp, *Holotrichia, Myllocerus laetivirens, Poekilocerus pictus* and *Eurybrachys tomentosa* were causing considerable damage to the acacias. *Acacia nilotica* provenance

had minimum infestation of termite, grasshopper and sapsucker. The seasonal fluctuation of insect pest population is recorded regularly to assess the extent of damage and to ascertain remedial measures.

Insect pest of *Tecomella undulata*

Patialus tecomella Pajni is a serious curculionid pest of marwar teak, (*Tecomella undulata*) and causes skeletonization in sapling and adult plants. In the nursery, *P. tecomella* is an alarming threat to the saplings because the complete bed of the saplings will bewas denuded, leaving the skeleton of the leaves. Study of the life cycle of this pest has been completed. Efficacy of different conventional insecticides has been studied. Application of monocrotophos (0.02%) was found as most effective.

Non insect pests

Eutetranychuys orientalis, commonly known as oriental redmite, has been recorded on neem with heavy infestation causing considerable defoliation at Jodhpur, in December. *E. orientalis* infestation has also been recorded on *Ailanthus excelsa, Albizia lebbeck, Bauhinia purpura, Cassia siamea, Moringa oleifera* and *Pongamia pinnata*. In *Azadirachta indica*, severe infestation by this pest has caused serious defoliation even in 3 years old plantations. Among young saplings in experimental cage, complete defoliation has been recorded. Monocrotophos at 0.04% gave satisfactory results in controlling this mite.

Mollusc damage

The mollusc *Laevicaulis alte* (Ferursac) was found infesting neem seedling in nurseries throughout arid regions. *Laevicaulis alte*, voraciously feed on all parts of the seedlings. It was observed that 10-15 cm high seedlings were eaten up completely and damage is beyond survival while older ones are able to revive when prevented from further attack.

The snail could be controlled effectively by collection and destruction of molluscs and the egg masses by dipping them in a container filled with sodium chloride solution. Regular surveillance is required to control this pest. The infested bed was treated with NaCl solution and allowed to dry for 2-3 days. This destroys the egg masses in the soil bed and prevents further infection. Severe outbreak of *L. alte* menace was noticed in neem seedlings in the nursery at Institute.

Insect pest of forest nurseries and their management

Plecoptera reflexa infested the seedlings of *Dalbergia sissoo* at Institute nursery and Lokswell nursery.

Myllocerus dalbergiae Rammurthy was found infesting *Moringa oilefera* seedlings. A lepidopteran defoliator was also found defoliating *Moringa* seedlings and the pest

is being identified.

In *Prosopis cineraria* seedlings, leaf galls and shoot galls were caused by midge *Contarina prosopidis*

Leaf miner *Lithocollectis* sp. infestation was observed in *Pongamia pinnata* seedlings. The insect makes a circular blotch in the leaf. It has been observed that a spray of monocrotophos @ 0.03% - 0.05% becomes essential in the nursery during the monsoon period, as maximum damage to seedlings was observed in the month of July to October.

Insect pest of seeds and their management

Caryedon gonagra was found infesting seeds of *Acacia nilotica* and *Prosopis cineraria*. The infestation can be controlled by sun-drying the seeds for 48 hrs before storing. The seeds of *Albizia lebbeck* were found infested by *Bruchidius albizziae*. The bruchid lays eggs on fresh green pods of *Albizia lebbeck*. The grub bores into the pod and feeds on the contents of the seed. It pupates inside the seed and emerges out by making a small circular hole. It does not multiply in stored conditions. The pods should be collected from tree. The seeds collected should be sun dried and flotation method technique should be utilized before sowing of seeds.

Taragama siva

Taragama siva, a polyphagous lasiocampid moth, is an important lepidopteran defoliator and is widely distributed in arid region but at Jodhpur and its adjacent localities, the infestation by this pest is all the more spectacular. More observations have been taken on the host species of *Taragama siva*. It also feeds and forms cocoons on *Acacia holosericea; A. nubica; Dodonea viscosa; Sesbania sesban; Ailanthus excelsa; Prosopis juliflora* and *Zizyphus mauritiana*.

BIOLOGICAL CONTROL

Efficacy of egg parasitoid, Trichogramma (strain) against defoliating pests

A large number of trichogrammatids, such as *T. chilonis, T. japonicum* and *T. achiaeae*, is widely distributed and is being considered key mortality factor parasitizing over 200 insect pests. The importance of insect parasitoids as biocontrol agents has initiated interests in various diet sources towards *Trichogramma* mass culture employing an effective host for parasitoid rearing. Therefore, eggs of *Corcyra* have been selected as the laboratory host for *Trichogramma*.

Collection of *Corcyra* eggs from the various laboratories was initiated to select the suitable and viable eggs by substantiating bajra, sorghum and wheat for the mass production of *Trichogramma* in the laboratory for augmentation programme. Eggs

obtained from the above culture will be used for inoculating further culture in the laboratory.

Host eggs, collected from the stock culture, were inoculated in bajra, sorghum and wheat grains to study the influence of above-said grain and their independent impact on the growth potential of *Corcyra*. The addition of groundnut in the culture medium showed further strengthening of the production of viable *Corcyra* eggs which are subsequently suitable for the mass production of active *Trichogramma* parasitoids against pests.

In view of the cost factor, bajra was chosen as a fair culture medium for *Corcyra* rather than wheat and sorghum as well as various bajra lines viz. MH-179, HHB-67, RCB-1C-924, RCB-2, C2-1C-922 and RCB-1C-9118 were tried in order to find out the suitable grain which is comparable to sorghum and wheat grains and also show very good resistance to *Tribolium* (predator) attack. The results obtained during the investigations emphasize the necessity of using appropriate diet category for *Corcyra* and for mass multiplication of and field activity of *Trichogramma*, which will yield an additional and conclusive information to manipulate parasitoid behaviour in biological control programme. This basic information also has applied relevance to the development of integrated pest management strategies.

Based on this work natural parasitization experiments is being studied by using Tircho cards as well as evaluation of the persisting natural enemy complex in the field.

MICROBIAL CONTROL

Evaluation of microbial pathogens against the defoliating pests

Laboratory and field studies on the Nuclear Polyhedrosis virus of Lepidopterous insect pests were studied. Virus isolated from the diseased larvae, viz. *Achaea janata, Atteva fabriciella, Catopsilia crocale,* and *Eligma narcissus,* were subjected to cross infectivity tests on insects which do not produce viral pathogens. This study was undertaken to find out the host range of NPV during the field visit to various plantations and nurseries in the peak incidence of various insect pests.

Nursery diseases and their management

Damping off in *Tecomella undulata*

During survey of various nurseries, viz. Osian, Tinwari, Phalodi and A.F.R.I., Jodhpur in March/April 1994, a severe incidence of damping off disease was observed in mother beds and polythene bags. A heavy seedling mortality was observed in patches and it was between 50-60% in seed beds and 15-20% in Polypots.

Tender seedlings up to 20 days old usually collapsed from the collar region and fell over the ground. Crowded seedlings were crumbled due to mycelial web. The pathogen is identified as *Rhizoctonia solani*. Soil drenching with bavistin (0.1%) was found very effective in reducing the incidence of the disease. The disease was first time recorded on *T. undulata* from India.

Seedling blight of *Hardwickia binata*

A severe incidence of seedling blight disease was noticed in provenance trial of *H. binata* in nursery. Seedlings started dyeing from top to downwards, the collar region turning into black due to accumulation of minute acervuli of *Colletotrichum capsici*. Finally the seedlings died. Detailed examination under a microscope studies exhibited dark brown to black setae and hyaline spores.

Percentage of mortality recorded was quite high ie 78.5% to 99.0% in various provenances of *H. binata*. Soil drenching with Bavistin (0.1%) or Blitox (0.2%) was given immediately to manage the disease. The percentage of revived seedlings was recorded as 60-80% in various provenances.

Management of Leaf blight disease in Neem

Severe incidence of leaf blight disease in neem, caused by *Alternaria alternata* was noticed in forest nurseries of arid region. Foliar spray of Blitox (0.2%) was applied at monthly intervals. The disease could be managed by three foliar spray at monthly intervals.

Incidence of Phoma leaf blight disease and its control

Incidence of leaf blight disease caused by *Phoma* sp. was noticed at Osian, Tinwari, Phalodi and Churu and Institute nursery. For immediate control, application of Cu-based fungicide i.e., Blitox (0.2%) at monthly intervals was found very effective.

Plantation diseases and their management

Disease incidence in Neem provenance trial

Shot hole disease caused by *Pseudomonas azadirachtae* is an important disease of neem in arid areas of Rajasthan. The disease occurs in October and it becomes severe in March-April, which causes early defoliation. The symptoms of the disease appear on the lamina in the form of circular brown spots which detached from the leaves and form shot hole appearance. The percentage of infection was noticed in 41 (Forty one) provenances.

Three provenances (Sonu, Bikaner and Mulug) were found free from the disease. In other provenances the infection ranged between 2.50 to 40 per cent.

Pathological problems in *Acacia tortilis*

Acacia tortilis is the most suitable species of arid and semi-arid areas particularly for sand dune stabilization. This species was found attacked by *Ganoderma* root-rot disease from Churu, Hanumangarh, Chhatargarh, Bikaner and Jaisalmer. Uprooting of diseased trees and making isolation trenches were recommended to check the spread of the disease.

Mortality in I.G.N.P. area

Mortality in *Acacia nilotica, Dalbergia sissoo, Eucalyptus hybrid* and Kinnoo was noticed due to various factors in I.G.N.P. area at stage I and stage II. About 40% mortality of *Acacia nilotica* was noticed due to *Ganoderma lucidum*, root rot disease at 1 KJD in 1978 plantation. Isolated trenches was recommended to the field staff to isolate the diseased plant to avoid the chances of spreading the pathogen to healthy ones. Mortality in *Eucalyptus* and *Dalbergia sissoo* was noticed at Chhatargarh and Hanumangarh area . The cause of mortality was due to adoption of faulty irrigation practices and sudden stoppage of watering. In some areas mortality of *Dalbergia sissoo & Eucalyptus camaldulensis* was observed due to water logging conditions.

STUDIES ON IRRIGATED PLANTATIONS IN IGNP AREA

A rapid reconnaissance survey of the whole of IGNP area showed that the main species planted (*Acacia nilotica, A.tortilis, Dalbergia sissoo, Eucalyptus camaldulensis, Prosopis cineraria, Tecomella undulata* and *Zizyphus mauritiana*) perform quite well. The survival percentage of various plantations ranged from 60% to 80%.

To have a quantitative understanding of the actual growth and yield, annual growth patterns and biomass are being studied in respect of the different species planted in the area. To this end, permanent sample plots of *Acacia nilotica, A. tortilis, Eucalyptus camaldulensis* and *Dalbergia sissoo* are being laid out at different sites.

GROWTH AND BIOMASS STUDIES ON NEEM

Growth studies of Neem in Gujarat region have been taken up. Permanent sample plots have been laid out in Palanpur and Gandhinagar Divisions for studying the annual growth increment. Measurements for 1994 have been recorded. A few trees have been marked for felling to prepare volume and yield tables for Neem in the region.

PHENOLOGICAL STUDIES ON NEEM

The study initiated in 1993 indicate that Neem remains almost evergreen throughout the year except for a brief period from February to April in most parts

of the country. Its flowering period is from late March to May and fruiting period is from May to August.

STUDIES ON LOPPING REGIMES OF FODDER TREES

The objective is to find out the effect of lopping on diameter and height so as to obtain optimum increment in diameter and height growth in relation to various degrees of lopping and at different seasons of lopping.

A plantation of *Acacia tortilis* was selected for the study. The lopping intensities (treatments) being followed are full, 2/3 and 1/3 of total crown length of the trees. The lopping seasons chosen are summer, monsoon and winter. The annual observation on height and diameter increments were recorded for various treatments. The data are being analysed.

MARKET SURVEY

A market survey regarding prices, demand and supply of MPTS of arid zone showed that *Acacia nilotica* is the preferred species among the local spp. followed by Neem and *Prosopis cineraria*, so far as timber and fuelwood are concerned. Though people have a preference for *Tecomella undulata*, it is not available in the market. A comparative statement of prices in respect of timber, fuelwood and fodder for Jaipur, Jodhpur and Ajmer markets is given in the following Table.

Species	Jaipur	Jodhpur	Ajmer
Timber (Price in Rupees per cubic feet)			
Acacia nilotica	133	153	118
Neem	125	-	118
Prosopis cinerria	120	-	
Ailanthus excelsa	64	-	60
Fuelwood (Price in Rupees per quintal)			
Acacia nilotica	111	113	89
Neem	97	90	92
Prosopis cineraria	91	116	73
Ailanthus excelsa	60		63
Prosopis juliflora		77	78
Fodder (Price in Rupees per quintal)			
Prosopis cineraria (Khejri loong)	250	350	250
Zizyphus mauritiana (Ber Pala)		200	250

BIOPESTICIDE

Biopesticide from Neem

The seed kernel extracts of *A. indica* are known to contain principles having anti-feedant, insect growth regulating and fecundity reducing properties against pests of agricultural and medicinal importance. A study was initiated to explore the possibility of utilizing neem constituents for the management of forest insect pests of arid and semi-arid regions.

Cold extraction of the neem seed kernel powder was done using methanol and it was tested against the larvae of *P. tecomella* collected from the field. The extracts were dissolved in 80% methanol and tested at concentrations of 0.001, 0.005, 0.010 0.050, 0.100, 0.300 and 0.500%. The area of leaves consumed in different treatment was measured; the antifeedant activity was computed and the data were subjected to analysis of variance (ANOVA).

The leaf area consumed by different instars and the percentage antifeedant activity computed at different concentrations are shown in following table.

Anti-feedant activity of methanol extract of neem seed kernel powder against *P. tecomella*

Conc. of extract (%)	Area of leaf consumed (mm^2)			Antifeedant activity (%)		
	II instar	III instar	IV instar	II instar	III instar	IV instar
0.001	42.00	144.67	192.00	35.97	16.53	45.04
0.005	26.67	122.33	159.33	59.49	29.47	54.45
0.010	19.67	99.00	132.67	70.00	42.79	62.04
0.050	17.00	77.33	97.33	74.03	55.37	72.10
0.100	10.33	48.67	71.33	84.25	71.90	79.51
0.300	5.33	24.67	43.67	91.94	85.80	87.49
0.500	0.67	8.00	18.67	98.95	95.39	94.67
Blank	60.67	165.00	356.67	7.83	4.78	5.60
Control	66.00	173.33	350.67			
CD (P = 0.05%)	4.12	9.25	15.98	5.80	60.02	4.18
CD (P=0.01%)	6.09	13.68	23.64	8.64	9.07	6.22

The amount of leaf consumed after 48 hours ranged from 0.67 (0.5%) to 66.00 mm^2(control) by second instar, ranged from 8.00 (0.05%) to 173.33 mm^2 (control) by third instar and ranged from 18.77 (0.5%) to 356.67 mm^2 (Blank) by fourth instar larvae. The area of leaf consumed in blank and control are on par with each other in all the stages indicating that 80% methanol alone has no effect on the feeding activity of *P. tecomella*. In all the stages, anti-feedant activity is less than 50% at 0.001% concentration while 0.005% concentration showed more than 50% antifeedant activity except for third instar larvae. Anti-feedant activity was maximum at 0.5%

concentration being 98.95, 95.39 and 94.67 respectively for second, third, and fourth instar larvae which is significantly superior than all other concentrations. Further, the effect is more with second instar followed by third and fourth instar. It is thus obvious that the methanol extract of neem seed kernel powder is active against *P. tecomella.*

For best extraction of the neem compounds from neem seed, methanol is used as a solvent. The quantity of the methanol extracts of Neem Seed Kernel (NSK) having strong insecticidal properties varies from tree to tree and from one location to another. In order to select best provenance, the defatted Neem Seed Kernel Powder (NSKP) of neem seeds collected from different Agro-Climatic Zones (ACZ) of Rajasthan, were cold extracted with methanol.The preliminary results obtained are given below:

Extract yield of Neem seed kernel collected from different agro climatic zones

Agro Climatic Zones	Methanol Extract %	Annual Rainfall (cm)	Annual No. of Rainy Days	Mean Temperature
1	2	3	4	5
ACZ-IA	16.80	32.53	17.60	27.5
ACZ-IB	13.97	25.37	15.70	25.5
ACZ-IIA	16.26	38.34	21.70	23.0
ACZ-IIB	16.40	63.84	28.90	25.5
ACZ-IIIA	15.46	61.36	33.00	23.0
ACZ-IIIB	16.13	57.77	29.90	24.5
ACZ-IVA	15.73	65.03	30.50	23.0
ACZ-IVB	17.20	76.17	34.70	23.5
ACZ-V	15.40	68.49	34.70	27.5

The results show that the quantity of methanol extract varies from 13.97% to 17.20% in different ACZ's. The maximum extraction of 17.20% was obtained from Banswara region and the minimum extraction of 13.97% was obtained from Sri Ganganagar region.

Biopesticidal properties of extracts of some arid zone plants

Sequential extraction of different parts of the plant of *Capparis decidua* viz. wood, bark, branches and seeds, was carried out with petroleum ether, chloroform and methanol exhausitively.

Percentage yields of the different extractives are shown in the following Table.

Percentage yields of extracts

Part of the plant	Petroleum ether	Chloroform	Methanol
Seeds	13.75	0.20	3.97
Wood	0.16	0.31	3.00
Bark	0.20	0.93	0.82
Branches	0.53	0.39	3.24

Acetone solutions of known concentrations were prepared from petroleum ether extracts and also chloroform extract in ethanol. Study of biocidal efficacy of above solutions in different concentration viz. 0.01%, 0.05% and 0.1% was undertaken against Babul defoliator *Taragama siva*.

NON-WOOD FOREST PRODUCTS

Fatty Oils of some important oil bearing plants of arid regions

(a) Determination of Fatty oils variation in Neem seeds

In view of the medicinal value and commercial importance of Neem oil, studies have been carried out to select the best provenance for higher oil content. Neem seeds were collected from nine agro-climatic zones of Rajasthan. Seed samples were analysed for their fatty oil content.

(b) Determination of variation of Fatty oil content in Salvadora spp.

Oil content of seeds of *Salvadora persica* and *Salvadora oleoides*, collected from 23 different localities of Rajasthan and Gujarat was estimated. Seeds of *S. persica* from Udaipur (Rajasthan) had highest oil content. Oil content of *S. oleoides* was highest in the seeds of Bhavanagar (Gujarat).

General Screening of Arid Zone Flora for Fatty Oils

Oil seeds of forest origin are the potential source of fatty oil of commercial importance in addition to the major oil seeds of Rajasthan. An attempt has therefore been made to make a survey of oil seed resources.

Seeds of various plants species were collected from different regions of arid zones for screening them for fatty oil with a view to augmenting the total production of oils. The examination of seeds of *Tecomella undulata*, *Cucumis callosus* and *Acacia leucophloea* revealed the presence of 18, 20 and 8 percent fatty oil content respectively. Examination of the obtained fatty oil by paper chromatography indicated the

following fatty acids in each of the sample: Palmitic acid, Stearic acid, Oleic acid and Linoleic acid. GLC analysis of the methyl esters of fatty acids is in progress.

Maintenance of garden plants of Arid and Semi-Arid regions

A Germ Plasm Bank consisting of about 50 plant species was maintained by carrying out soil working, weeding, tending and watering operations. Anti-termite operations were also undertaken by adequate application of Basudin and Monochrotophos by trenching method.

FORESTRY EXTENSION

UNDP Project

In addtion to strengthening the research base, this project is intended to plan and evolve extension method for transfer of technology developed to the user agencies. Accordingly, under UNDP project 10 demonstration villages have been selected in two clusters to carry out work to achieve the objective of creating an awareness among the people at the grass root level about the importance of trees. It is hoped that these 10 villages would emerge as model villages in so far as plantation and afforestation activities are concerned during the project period 1992-1997 and the gains would encourage and motivate others to emulate the example.

The villages were selected using parameters such as poor socio-economic status of the people and easy accessibility.

The following activities have been carried out in these 10 villages :

1. An extension team consisting of one male and one female extension worker was entrusted the responsibility for each village. The involvement of female extension workers was considered absolutely necessary to overcome social barriers and communicate effectively with the village women. A door-to-door socio-economic survey, covering the total population, was conducted in September-October 1994. Detailed socio-economic profile of the target groups was gathered, which will help in evaluating the gains at the end of the project period.

2. Based on the local soil and climatic conditions, superior quality seedlings of Arid Zone species were supplied to the villages for homestead plantations, block plantations in their private fields and bund planting on their field periphery. During the year, 11600 plants of species like Neem, *Albizzia lebbeck*, Drum stick, *Pongamia pinnata*, etc. were supplied.

3. Extension workers of the Institute provided the necessary expertise for plantation techniques, spacing and schedule of irrigations etc., whereas the

villagers themselves put in the labour inputs and FYM etc. The seedlings were supplied free of cost.

4. Training cum demonstration programmes were organised for these villagers. During this demonstration-cum-training programme, the villagers were given on spot demonstration regarding nursery and plantation techniques for important arid zone species as well as soil and moisture conservation measures.

5. The Institute has successfully raised and supplied 10,000 seedlings of *Atriplex* spp. (Australian salt bush) to the Project Director, Integrated Watershed Development Project, Jodhpur, for plantation in arid-saline areas.

The Institute has also taken bamboo plantation to try out bamboo in arid region and the initial results are encouraging.

Further details are given in Annexure-VI.