

ORGANISATION OF RESEARCH WING OF HARYANA FOREST DEPARTMENT

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ACTIVITIES OF RESEARCH WING OF HARYANA FOREST DEPARTMENT

Additional Principal Chief Conservator of Forests (Development) with headquarter at Panchkula, is the head of research wing of Haryana Forest Department. He is assisted by Conservator of Forests, (Research) headquartered at Pinjore. The following main activities are being carried out by the Research wing of Haryana Forest Department:

- **Bio-diversity Conservation**
- **Tree Improvement Works**
- **Species Introduction**
- **Introduction of Exotics**
- **Provenance Trials**
- **Progeny Trials**
- **Nursery Research**
- **Medicinal Plants**
- **Agro Forestry Research**
- **Testing Of Species For Problematic Soils**
- **Propagation of Endangered species through Tissue Culture**
- **Raising of clonal plants in Mist Chambers**
- **Germination And Viability Studies**

Introduction

Research related to forestry activities was initiated in Haryana Forest Department ever since the birth of separate state of Haryana from its parent state Punjab in 1966. DFO research headed then forestry wing. Later on research wing was headed by conservator of forests (development). In 2006, erstwhile research division was elevated to level of circle by merging research and seed collection divisions, which is now being headed by conservator of forests. In August 2009, two divisional forest officers one DFO Research and another DFO Seed have been posted in research circle. Accordingly two divisions viz. research and seed have been created

The main function of research wing is to conduct research on forestry matters, collect seed from superior trees and supply it to plantation divisions. There are four geographical zones in the state namely Shivalik, central plains, Semi arid western zone and southern Aravali region. The agroclimatic conditions and silvicultural conditions vary in these regions. To cater to the forestry research needs of the entire state as per difference climate conditions, research stations have been established at Seonthi, Bithmara, Jhumpa and Sohna. We have also established modern seed processing unit and seed testing laboratory at Pinjore. There are well established modern high tech seed and research nurseries in the state equipped with green houses. All seed and research nurseries have vermiculture and compost pits. All weeds and organic matter produced or generated in the nursery is used for the production of compost. All research nurseries are producing quality seedlings including tall plants. Forest research includes screening of species for problematic soils like alkali, saline, sand dunes and denuded Shivalik hills, to grow crop under poplar and eucalyptus for maximum environmental and economic returns, testing of clones of different species; establishment of Clonal Seed Orchards, Seedling Seed Orchards; selection and marking of plus trees, identification and setting up of seed stands, selection of suitable species and their clones for agroforestry specially for low rainfall arid region; creation of germplasm bank for economic and endangered species; progeny and provenance trials; to suggest suitable package and practices for cultivation of medicinal plants; identification of suitable and high yielding species for agroforestry; to conduct studies on dying of Shisham and Kikar trees and to identify suitable cultivars tolerant/resistant to *Fusarium and Ganoderma fungi*; to suggest suitable package and practices for the control of pests and diseases of important tree species of Haryana like poplar, eucalyptus etc.

Forestry Research in The Past: The following are the achievements of the forest department Haryana since the inception of Haryana state in 1966.

1. **Evaluation of growth of eight arid zone species in the northern arid region of Haryana.**
2. **Introduction trial of different species in Shivalik hills.**
3. **Species/provenance trial of eucalyptus.**
4. **Evaluation of eucalyptus species and provenances for northern region of Haryana.**
5. **Afforestation trials for Morni hills.**
6. **Studies on tree and crop interaction in Populus deltoides G3 on the growth and yield of wheat crop under irrigated conditions.**
7. **Development of technology for afforestation of sodic soils (leguminous species).**
8. **Work study on uprooting of Lantana.**
9. **Observation on the performance of Acacia albida.**
10. **Trial of fruit species in sodic soils.**
11. **Propagation of Shisham: Trial at Bir Shikargah.**

12. Eucalyptus full sib (clonal) progeny trial and clonal garden.

13. Clonal Teak Orchard.

Brief notes on the above mentioned research work is given as under:

1. Evaluation of growth of eight arid zone species in the northern arid region of Haryana.

Various species of indigenous and exotic trees were tried at Jhumpa Research Station in Bhiwani district, which is true representative of arid zone. The purpose was to screen various species for arid zone of Haryana having annual rainfall of about 250 mm and also to stabilize sand dunes besides providing fuel wood and fodder to the people. The species included *Acacia mulga*, *Acacia albida*, *Acacia tortilis*, *Acacia nilotica*, *Roheda (Tecomella undulata)*, *Jand (Prosopis cinerea)* and *Eucalyptus camaldulensis*. The results were as under; the top most show the best and lower most the poorest:-

Fatherbia albida (Acacia albida)

Eucalyptus camaldulensis

Vachellia tortilis (Acacia tortilis)

Vachellia catechu (Acacia catechu)

Prosopis cineraria

2. Introductory trial of different species in Shivalik hills

The experiment was started during 1983 in Bir Shikargah forest of Morni division to find suitable species which can grow well in Shivalik foot hills which can grow well under well drained and loamy soil conditions. The following species were tried.

Brousonetia papyrifera (Paper Mulberry)

Eucalyptus hybrid

Dalbergia sissoo (Shaisham)

Bombax ceiba (Indian Red Cotton Tree or Seemal)

Terminalia tomentosa (Sain)

Albizia procera (White Siris)

Holoptelea integrifolia (Hill Papri or Kanju)

Grevillea robusta (Silver Oak)

Cedrella toona (Tun)

Terminalia bellerica (Beleric myrobalan) or Baherha

The results revealed that in the case of *Eucalyptus*, *Grevillea robusta* (Silver Oak), *Terminalia bellerica* (Beleric myrobalan) or Baherha, and *Terminalia tomentosa* (Sain), the survival was satisfactory. *Dalbergia sissoo* (Shaisham) and *Albizia procera* (White Siris) showed excellent growth and survival. However, in the case of *Brousonetia papyrifera*

(Paper Mulberry), *Holoptelea integrifolia* (Hill Papri or Kanju) and *Cedrella toona* (Tun), neither the growth nor the survival was satisfactory.

- 3. Species/provenance trial of eucalyptus:** Various Eucalyptus species and provenances were received from Eucalyptus Research Station, Hyderabad, in October, 1984. The experiment was conducted at Saraswati in Kaithal district. The results showed that provenances of *Eucalyptus camaldulensis* and *E. tereticornis* were promising ones.
- 4. Evaluation of Eucalyptus species and provenances for northern region of Haryana:** The study was conducted at Jhumpa with a view to evaluate growth, survival and adaptability of 12 provenances of *E. tereticornis* and one provenance of *E. hybrid*. The results indicated that ET2 of *E. tereticornis* were superior to the other provenances of *E. camaldulensis* and *E. hybrid*.
- 5. Afforestation trials for Morni hills: Studies on tree and crop interaction in Populus deltoides G3 on the growth and yield of wheat crop under irrigated conditions.**

This experiment was conducted to determine the effect of one sided row of poplar on growth and yield of wheat. The study was done at farmer's field in Sherpur village of Yamunagar district in 1986. It was concluded that growing poplar with wheat in single row on southern aspect of field in east western direction combined with crop under irrigated conditions is economically viable.

- 6. Development of technology for afforestation of sodic soils (leguminous species)**

The study revealed that the dug up soil mixed with 3kg gypsum, 20 gm urea, 50 gm single super phosphate, 25 gm muriate of potash, 5 gm B.H.C., 0.2 gm Zinc sulphate and two kg rice husk when refilled and planted with seedlings gave best results. Among five species tried, *Prosopis chilensis* was the best, followed by *Tamarix articulata* and *Acacia nilotica*. *Pongamia pinnata* survived but did not put on good growth during first three years. *Albizia lebbek* was not found to be a suitable species for sodic soils.

- 7. Work study on uprooting of Lantana:**

Lantana an exotic weed locally called Balari is obnoxious weed. It has replaced local biodiversity and is Invasive Alien Species (IAS). A work study was conducted in Bir Shikargah forest to study the cost of its uprooting. Three types of areas were selected for uprooting depending upon the density of Lantana. Traditional implements which were used by the local labourers were used for the uprooting. It was found that the number of mandays required for the cutting and uprooting of Lantana were 84, 196 and 208 days for 0.45, 0.70 and 0.85 density respectively. Thereafter, the uprooting was done with Lantana extractor during different parts of the year. It was found that the number of days required for uprooting of Lantana during May and after rains were 60 and 100 respectively per hectare. For extraction of root stocks of Lantana after the rains with the extractor with the aerial portion cut only 60 days were required.

8. Observation on the performance of *Acacia albida*:

Acacia albida is a species which can grow very well under arid conditions. Its adventitious roots being very deep do not compete with the crop. It produces profuse suckers and therefore be easily propagated by the root suckers. It is a good species for agroforestry as well. It was concluded that though it is a good species for agroforestry in arid areas but its wood is not suitable as timber as it is badly attacked by Pin Hole Borer insect. The wood is also not a good fuel wood species either due to low calorific value.

9. Propagation of Shisham : Trial at Bir Shikargah:

A study was conducted to compare the growth of seedlings raised from root shoot, root and shoot cuttings. It was found that plants raised from root shoot cuttings performed better compared to other two techniques.

10. Trial of fruit species in sodic soils:

A study was conducted at Bichhian Reserve Forest in Kaithal district in 1991 to study the performance of different fruit species in sodic soils having pH more than 10.5. The species included were Jujube (Ber), Jamun, Bael, Chickoo, Mango, Guava, Karaunda, Date Palm, and Phalsa. None of the plants were found economically suitable for sodic soils.

11. Eucalyptus full sib(clonal) progeny trial and clonal garden

The experiment was conducted at Seonthi in 1993. Seven clones procured from Bhadrachalam and six from TERI and one local as control were planted at 3m by 3 m spacing. Bhadrachalam clones were found better.

Germination Studies: Under Haryana conditions germination studies are being conducted for all species. We have concluded germination studies on Neem or Margosa Tree (*Azadirachta indica*), Jamun or Black Plum (*Syzygium cumini*) and Sita Ashok or Sorrowless Tree (*Saraca indica*). Our findings are that in the case of neem the seeds, which are supposed to have viability only upto one week or so, remained viable in the nursery and laboratory upto 61 days. Similarly Jamun seeds also remained viable upto one and half months.

Germination studies on *Saraca indica* (Ashok): A rare and endangered medicinal and religious plant.

Sorrowless Tree or Ashok is not common in Haryana. It has lots of medicinal value. The bark of this tree is useful in urinary infections, high blood pressure and stomach ailments. It does not grow in Haryana as natural species either. We collected the seeds of this species from the nearby areas of Pinjore. We collected vital statistics for this species and the results are as under:

Length of pods: upto 19.5cms

No. of seeds per pod:	One to seven
No. of seeds per Kg:	110 to 120 (At the time collection as the seeds are to sown fresh)
Germination Period:	(Treated 26 days to 1.5 Months) (Germination 18 days to 1.5 Months)
Percent Germination:	80.12%
Viability Period:	1.5 Months

Biodiversity Conservation:

Many species of plants and animals in Haryana are threatened with a danger of extinction. Each and every species plays very important role in conserving ecology. The fact that only 10 to 15 percent species have been described out of total range of 30 lakhs to 5 crores, proves the necessity to conserve all species, as extinction of some species may lead to ecological disaster. It is with this aim that Haryana Forest Department has identified the conservation of species of plants and animals in its priority area. Main species of plants which have been identified for this purpose are: Hararh or Chebulic Myrobalan (*Terminalia chebula*), Baherha or Beleric Myrobalan (*Terminalia bellirica*), The Sacred Barna (*Crataeva religiosa*), Tat Bharhang (*Oroxylum indicum*), Bakar (Premna barbata) in northern Haryana, Guggal (*Commiphora mukul/ Commiphora wightii*) in Aravalli hills and Jand/Shami (*Prosopis cinerea*), Marwarh Teak (*Tecomella undulata*) and Hingot (*Balanites aegyptica*) in western and southern Haryana. Various aspects related to their propagation, growth behaviour, susceptibility/ tolerance to pests, frost and drought are being studied. Ex situ and in situ conservation of medicinal plants has also been taken up. Ten hectares area of Guggal under MPCA was taken up at Rasoolpur forest in Mahendergarh district in February 2013. The area is being maintained since then.

Tat Bharang (*Oroxylum indicum*): Now endangered species, has great medicinal value

The seed is collected in month of February-March. Its seed has a dormancy of about one month. After one month its germination capacity is 70-80%.

Tree Improvement Works:

Tree improvement is the application of knowledge of art and science to produce trees capable of performing better than others. The aim of tree improvement is to produce superior genetic resource for future by improving growth, pest resistance and other desirable traits like straight bole and quality of fiber etc. The following tree improvement works are being taken up in Haryana:

Selection of Candidate Plus Trees (CPTs):

A plus tree is a phenotypically superior tree, in any given population in terms of height, bole, crown or any other desirable trait. It is of about half the rotation age, has crown not more than one third of its bole, has straight bole with less taper and produces superior seeds. We have marked a total of about 2000 trees belonging to Eucalyptus, Sissoo (*Dalbergia sissoo*), Kikar or Gum Arabic, *Vachellia nilotica* (*Acacia nilotica*), Khair or Black Cutch (*Vachellia catechu*), Neem or Margosa Tree (*Azadirachta indica*), Shami or Jand (*Prosopis cineraria*) and *Ailanthus etc.* Most of these trees belong to Eucalyptus, Sissoo and Kikar.

A CPT of Eucalyptus



Establishment of Seed Orchards:

A seed orchard is an area where plantation of genetically and phenotypically superior trees is isolated to reduce pollination and varietal admixture from the nearby inferior sources. It is established by setting out clones or seedling progeny of trees selected on the basis of certain desirable traits. A seed orchard is extensively and intensively managed to produce superior and abundant seeds. There are two types of seed orchards:

Clonal Seed Orchards (CSO): CSOs are raised from selected clones which are propagated by vegetative means i.e. by budding, grafting, layering, stooling, cuttings and tissue culture. At present we have established CSOs for Eucalyptus and Sissoo. Our CSOs have all improved clones brought from the reputed organisation. Year wise seed collection is given below:

	Year of collection	Seed collected in Kgs
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Seed collected from CSO of Eucalyptus	2014-15	9.5
	2015-16	3.0
	2016-17	5.5
	2017-18	9.5

The seed collected from CSOs of Shisham during the last five years is as under:

	Year of collection	Seed collected in Kgs
Seed collected from CSO of Shisham	2013-14	1200
	2014-15	2500
	2015-16	1500
	2016-17	1200
	2017-18	1000

Eucalyptus Trials:

Establishment of Clonal Testing Area (CTA) for eucalyptus: 33 individuals in three replications (33x9bx3) =891 seedlings in RBD of nine plants from the same treatment were planted in the month of March, 2002 at Bithmarha at a spacing of 3x3 meters. The promising clones are S-C 271, SC-6. The trial has now been concluded.

Eucalyptus Provenance Trial 0.5 Hectare ((2001-2002): 450 plants from six Australian seeds lots were planted during August, 2002 at Bithmarha at spacing of 3x3 m in 18 randomized blocks in three replications taking 25 seedlings of same seed lots in one block. Seed lot number 20231 and seed lot number 18548 have done well. The trial has now been concluded.

CTA JK Papers, 2.3 hectares (2003-2004): A total of 2500 plants 2208 from JKSC and 292 local in three guard lines were planted in the month of November, 2003 at a spacing of 3x3 m in four replications. Clones planted were 2, 4,5,8,9,11,17,19,16,6 were planted. The clones which proved better are 2, 4 and 8. The trial has now been concluded.

Eucalyptus CTA Haldwani 0.4 Hectare: 448 plants of four cultivars (412 in plot+ 36 in lines) were planted at Bithmarha in the month of November, 2003 at a spacing of 3x3 m in the year 2003-2004. Clones planted were G1, G2, G17, G22; Best colnes were G1 and G17. The trial has now been concluded.

Eucalyptus CTA Australian Seedlings: 1.35 Hectares(2003-2004): A total of 1448 seedlings from 64 cultivars (1368in plot+120 in guard rows) were planted at Bithmarha in a plot of size 90by 150 m at spacing of 3by 3m in the m/o Nov.,2003 in four replications. The best clones were 26, 34 and 88. The trial has now been concluded.

Eucalyptus Trial of CPTs of Haryana: 1.2 Hectare (2003-2004): A total of 1248 seedlings from 33 CPTs (1148 in plot+ 100 in guard rows) were planted in Nov. 2003 at Bithmarha at

spacing of 3m by 3m in four replications. The best seedlings belonged to group 20-FN, 14HHR. The trial has now been concluded.

Evaluation of Clones CSO's CPT's & Progenies : The germplasm of Eucalyptus in the state was evaluated in May 2012. The results are as under:

- Clone No.105 topped the list with respect to biomass production both in normal and high pH soils. It has perfect clean and round bole. Based on its performance throughout the state, now it is being taken up for multiplication in mist chambers.
- Clone No.132 occupied second in overall performance.
- Clone No. 83, 272, 286, 159 & 84 are suitable for normal soils.
- Clone No.10 occupied 3rd position in performance. However, it has proved most susceptible to Gall Wasp. Hence, for the time being it has been rested for propagation. The promising clones found promising after this trial have gone to the mist chambers and seed orchards for producing superior planting material.

Sissoo: Shisham or Sissoo is the most important species of Haryana. It is also called Tali locally. So for 200 CPTs of this species have been marked and we are in the process of selecting some more CPTs. We have identified two local cultivars of this species. These are called Tahala and Tahali. The former has thick bark and has vertical fissures only: whereas the latter has both vertical and horizontal thin fissures on the bark giving the appearance of biscuit like flakes. Tahala has more of sapwood and less of heartwood and, therefore, fetches very less price in the market. On the other hand Tahali has very thin heart wood and, therefore, fetches very good price in the market. We have also planted 30 FRI clones in the state at Bithmarha Research Station in Hisar district. These clones are 9,10,14,19,33,38,41,42,44,51,52, 60,62,66,76,79,94,101,103,105,106,108,204,215,239,324,361,384,394 and one local. It has been found that the clones of 100 series are producing quality seed. All these clones in general and clone no. G-113 in particular is doing very well in the state of Haryana. A bulk of plants in the nursery are being raised from this clone. However, the problem of drying of Shisham still remains. Number of young plants have to be removed every year as they are dying premature. FRI variety No.14, which is said to be tolerant to *Ganoderma* & *Fusarium*, has been introduced in the year 2009. It will remain under observation for another five years. Till now it is doing very well.



Tahala cultivar of Sissoo

Progeny Trial of Shisham: A total of 2.6 hectare area was planted at Bithmarha in the year 2004 with the progeny of CPTs belonging to Haldwani area. Some of the CPTs are: CG32, B266, TH2, TH6, CPH40, TH5, SPH11, SPH14, SPH13, LP1, CPH39, EH4, CG36, PH1, SPH12, EH4, LP7, LP10, SPH12, LAM 3, LAM4, B281, TH 27 and TH4. The progeny trial is under observation and will remain under observation for another five years.



Tahali cultivar of sissoo

Seed orchard of Sissoo at Bithmarha

A CSO containing all superior sissoo clones brought Gonda, Haldwani and elsewhere were planted in Bithmarha in 1995. The area was ploughed and harrowing was being done regularly as a part of the maintenance of the orchard. But the orchard was severely infested by *Fusarium* and *Ganoderma lucidum* fungi. We learned that these fungi also enter through the root hairs. We stopped the harrowing but the damage had already been done. So, this served as an example of sick plot. We continuously removed the dead trees every year but decided not to fell the healthy ones. After 23 years clone number 219 is still standing tall. May be this clone will finally prove to be tolerant to *Fusarium* and *Ganoderma lucidum*. We will observe the dying and drying phenomenon for the remaining survived trees for another five year to draw the final conclusion.

Research Activities at Forest Research Station, Seonthi (Distt. Kurukshetra)

Seonthi Research Station is primarily meant to conduct research on eucalyptus. Forest Research Station Seonthi was established in the year 1989 for carrying out forest related research activities to cater to the local needs of Forest Department, Haryana. Out of the total 474 acres of Seonthi Reserve Forest, an area of 200 acres has been earmarked for research activities. The soil of the area is clayey with pH ranging from 8.5 to 9.6. At present following main activities are going on at this research station:

1. Establishment of Clonal Seed Orchards (CSOs) of Eucalyptus
2. Establishment of Clonal Multiplication Areas (CMAs) of Eucalyptus
3. Clonal Propagation of Eucalyptus in Mist Chambers
4. Tissue Culture Unit (TCU)
5. Progeny trial of *Eucalyptus tereticornis* (Clonal Seedlings)
6. Provenance Trial of *Eucalyptus tereticornis*, *E. camaldulensis* var. *robusta*

Establishment of Clonal Seed Orchards (CSOs): The brief description of various CSOs established at Seonthi is as under:

1. CSO 1997-1998 (Area 6.7ha): In this CSO 22 clones of ITC series viz. 1,3,4,6,7,8,9,10,27,71,83,99,105,115,116,119,128,130,132,142,147,157, 271 and 277 were planted in Randomized Block Designs (RBDs) in 42 blocks. Three guard rows of clone number 3 & 7 were also planted. This CSO is producing very less seed and that too on the top. The performance of none of the clones is satisfactory and hence the trial has been concluded.

2. CSO 1998-1999 (Area 1.5ha): In this CSO 19 clones of ITC series viz. 3,7, 27,71,83,84,99,134,159,161,265,266,269,272,273,286,290 and 365 were planted in one block but each clone was randomized 45 times. For comparison local seed originated plants were also planted randomly. A guard row of ITC no.7 was also planted. Clone No. 71, 84 & 27 are best performing clones. Healthy plants of these clones has been retained as seed bearers. A team comprising the seed experts of FRI Dehradun has visited our seed orchards. They have given some valuable guidance for the maintenance of these CSOs. This includes the retention of minimum number of trees and application of nutrients and and flowering and seed promoting hormones. It is worth mentioning that these trees are not now producing sufficient seed and we are likely to replace them within next two to three years.

Mist chambers at Seonthi for clonal propagation of plants



Mist chambers

3. CSO 2005-2006 (Area 2.0 ha): In this CSO 3 clones of ITC series viz. 3,6,7 raised in mist chambers at Seonthi were planted in single block. No guard row has been planted in this case. The seed is being collected but the seed bearing is not satisfactory.

These CSOs have been evaluated in 2012 for biomass production and other traits like pest attack and bole characters and accordingly the inferior one have been removed. Hygiene felling has also been completed in this CSO. The seed is being collected but the seed bearing is not satisfactory.

Establishment of Clonal Multiplication Areas (CMA):

1. CMA 1999-2000 (2.5 ha): This CMA was planted with six Bhadrachalam clones namely 3,7,8,10,27 and 130. Amongst the clones planted in this CMA, clone numbers 27 and 128 are being used at present for taking cuttings and other clones were uprooted as they had lost their vigour. The remaining are also being removed in a phased manner as the ramets from these clones are not rooting well in the mist chambers.

2. CMA 2003-2004 (0.89 ha): In this CMA six clones of JK Papers viz. JKSC5, JKSC2, JKSC2N, JKSC4, JKSC8, JKSC11 of Raighadha Orissa and one clone of Bhadrachalam origin viz. ITC 6 were planted. Clone No. 4 & 8 have performed better hence these clones has been retained for further multiplication rest of the clones have been culled. However, these clones are also being removed in a phased manner as the ramets from these clones are not rooting well in the mist chambers



3. CMA 2004-2005 (10 ha): In this CMA six clones of Bhadrachalam origin viz. ITC 3, 7,6,10,99 and 130 were planted. These clones were integrated with local clonal plants raised after felling one eucalyptus tree at Western Yamuna Canal (WYC or WJC) and then multiplying it from the coppice shoots taken from it. Only clone number 130 is doing well. However, being old CMA, the plants are being uprooted and these will be replaced with fresh plants of clone number 130.

4. CMA 2006-2007 (8 ha): In this CMA five clones of ITC series viz. 3,7,130,271 and one local Binjalpur clone have been planted. Clone No. 130 & 271 have been found resistant to Gall wasp & Little leaf diseases hence will be cut at stool height in 2018-19 for taking cuttings for further propagation. Rest of the clones will be removed from this CMA.

5. CMA 2007-2008 (5 ha): In these CMA seven clones of ITC series viz. 3, 7, 71, 99,130 and 271 have been planted. Clone No. 130 & 271 have been found resistant to Gall wasp & Little leaf diseases hence will be cut at stool height in 2018-19 for taking cuttings for further propagation. Rest of the clones will be removed from this CMA. Gradually fresh CMA will be planted with 271 as well as the plants have become old.

6. CMA 2008-2009 (5 ha): In this CMA six clones of ITC series viz. 52,83,105,130,271 and 290, three clones purchased from Pragati Biotech Hoshiarpur viz. 316(FRI) 413 (FRI),526 and one from Punjab Forest Department i.e. 2070 have been planted. Clone No. 316, 413, 130 & 271 have been retained for further propagation and rest to the clones are being removed from this CMA.

CMA 2011-12 : In this CMA six clones of ITC series viz. 52,83,105,130,271 and 290 , three clones purchased from Pragati Biotech Hoshiarpur viz. 316(FRI) 413. Clone No. 83, 130, 271 & 413 have been cut at stool height for taking cuttings for further propagation. The area will be planted with fresh clones in a year or so.

Clonal Propagation of Eucalyptus in Mist Chambers:

- This facility was established for clonal propagation of *Eucalyptus* in 2001. At present nine selected clones of *Eucalyptus* viz 83, 105, 130, 271, 288, 290, 413, P 23 and P 45 are being propagated. These are fast growing, high yielding and diseases resistant clones and give 1.5 to 2 times more yield than the seed raise plants as indicated by the research data.
- The planting stock is obtained from well developed CMA (Clonal Multiplication Area) available in the Seonthi & Bithmara.
- In 2001, the capacity was to plant 65,000 cuttings in one batch in 5 mist chambers which was later increased to plant 1,53,500 cuttings in 11 mist chambers in 2002 in one batch. In 2008, with certain modifications in existing mist chambers, the planting capacity was increased to 3,38,000. At present 21 mist chambers are functional at Seonthi and Bithmara with an annual capacity of raising of 15 lakhs clonal Eucalyptus plants.
- Cuttings are being propagated in state of Haryana in fully automatic mist chambers under high temperature (45⁰C) and high relative humidity (>90%) with the application of rooting hormones. The time period required to produce a well developed plant from a cutting is 16 to 20 weeks. The normal period of operation for mist chambers under climatic conditions of Haryana is from April to December in which maximum four batches of cuttings can be planted depending on the air temperature and availability of planting material.
- Success percentage at this facility for the cutting planted to the plants produced is more than 75% which is the highest ever reported for this species for commercial production in the country.
- These clonal plants are suitable for planting on field bund and boundaries, in block plantations and in Agro forestry systems as the trees are tall and straight growing, have self pruning ability, can be planted on variety of soils and require less management as compared to the other commercial species like Poplars.

Clonal eucalyptus plants

- **Plant Tissue Culture Unit (PTCU):**

A Plant Tissue Culture Unit (PTCU) has been established at Seonthi and it has become operational. The species like *Dalbergia sissoo*, *Corymbia*, *Salvadora*, *Tecomella*, *Eucalyptus*, *Bamboo*, *Capparis* etc. have been identified for micro propagation. As of now success has been achieved in shoot proliferation in *Eucalyptus* & bamboo. However, the success in rooting of proliferated shoots has not been achieved. The PTCU is being run under the supervision of experts.

- **Provenance Trial of *Eucalyptus tereticornis*, *E. camaldulensis* var. *robusta* ;); 2001-2002 (Area 0.6):** In this trial eight No. of seed source and 75 plants from per source were planted at Bithmarha in three replications according to RBD design to evaluate the source-cum- provenances of eucalyptus.

1. **Kikar/Gum Arabica:** This is often a neglected species but the fact is that it is really poor man's timber. Right from windows and doors to bullock cart, benches and fuelwood, Kikar is extensively used in rural Haryana. We are testing the provenances of this species brought from all over the country at Bithmarha for bole, crown, and branchiness, resistance to pests and tolerance / resistance to frost. PTA for this was established in the year 1998. After 14 year we have found that the provenance of Dausa (Rajasthan), M.P. and Bhiwani have performed best under our conditions. We are collecting seed from these trees and raising plants in our nurseries.

Neem: It is one the best shady trees of Haryana for afforestation in western and southern Haryana. Nowadays, it is valued more as medicinal tree rather than timber species. Extraction of antifeedant and bio pesticide from its kernels has attached greater importance to it. We have brought its provenances from all over the country to test them for good bole and crown and tolerance/resistant to frost. 255 plants from 51 CPTs marked by FRI Dehradun from different parts of UP and Haryana were planted in the month of August, 2001 at a spacing of 6x6m to test the suitability of these CPTs in agroclimatic conditions of this area. Best CPTs are: Palwal-8 and Bhiwani-8 after ten years observations we have concluded that Haryana germplasm is the best.

2. **Poplar:** This is another excellent species for agroforestry. Poplar is very popular among the farmers especially of Ambala, Yamunanagar, Kurukshetra, Kaithal and Karnal.

However, it has limited range as it can grow only along Yamuna belt and requires lot of care. In 2012 we had introduced latest WIMCO, FRI and Pantnagar clones. We now have 28 latest clones of poplar. We have found that WIMCO clones number 109, 110 and Pantnagar clone number PP-5 perform well under Haryana conditions.

Establishment of Germ Plasm Bank: The purpose of establishing germplasm bank is to multiply genetically and phenotypically superior parents. This is done to preserve the genetic base of the plant. The germplasm banks form the future source of superior genetic material. We have started the establishment of germplasm bank for two species viz. Jamun or Black Plum (*Syzygium cumini*) and wild Mango (*Mangifera indica*). It is believed that there are over 50 cultivars of Jamun in and around Haryana. These cultivars start yielding delicious ripe Jamun fruits from the beginning of June and continue giving fruits upto early August. Not many efforts have been made to put them at one place and multiply them with the aim that the fruits are easily available throughout the season. Besides there are certain cultivars which are delicious but are known only to local people. One such example is "Shakarpara" cultivar of Jamun which has been named after popular sweet Shakarpara. The fruits of this cultivar are having very small and thick and soft pulp. Which when put in gets dissolved like Shakarpara. Till now we have identified 12 such cultivars and have planted at Manakpur in the year 2010. The performance as regards the growth is good. However in this 8 year old trial no fruiting has yet started.

Biofuel Studies: For conducting studies on biofuel species we have selected two species. One is Pongam oil tree or Badam Papparhi (*Milletia pinnata*) (= *Pongamia pinnata*) and other is *Jatropha curcas*. Later was planted over an area of 6 hectares at Jhumpa Research Station in Bhiwani district in the year 2006. *Jatropha curcas* plants here as well as in other parts of Haryana have been severely affected by frost during winter. All plants die as a result of frost bite followed by dieback disease. Every year new shoots emerge from the ground following the summer season. On the basis of poor seed yield, diseases and other parameters we have concluded that *Jatropha* cultivation is not economically viable in Haryana.



Species Introduction: Increased biomass production, resistance to frost and drought are some of the desirable characters in any species. We do not have many valuable timber species in Haryana. It is with view *Swietenia mahogany* has been introduced in Shiwalik foot hills in 2010. It is growing very well in Chandigarh as ornamental tree. It is frost resistant and one of the best 50 timbers of the country. We have planted 200 plants of this species in Khoi Bhagarni forest of Morni Range. The height and girth data is being taken annually. Its tolerance to frost and diseases is also being studied. Initial trend show that it may not perform well under Shiwalik conditions.

Introduction of *Melia composita*: *Melia composita* Syn. *Melia dubia* is one of the fastest growing species suitable for growing under agroforestry. It has been introduced in the state in 2005. FRI has also laid experiments for testing various clones. The results are highly encouraging. The species has wider adaptability and success. The price of timber of this species in the market are more than Euc. & Poplar. Its timber is used in furniture and other day to day items. It is going to give boost to agroforestry in the state.

Screening of Eucalyptus clones

Eucalyptus clones have been screened against *Leptocybe invasa* and no.288 has been found to be the most tolerant and no.10- most susceptible.

Silvicultural & inventorization studies

A brief description of the research conducted on the issues related to the need of present day forestry in general and Haryana in particular is given below:

1. Raising Neem/Margosa Tree (*Azadirachta indica*) by Root-Shoot cuttings

Neem or Azad Darakht-e- Hind (That is why *Azadirachta*) finds an important place in India wherever it grows. Of all the plants that have proved useful to humanity, neem is distinguished by its astonishing versatility. Though it is a very good timber as well but it is valued more for religious, environmental and medicinal attributes. Neem is mentioned in many ancient texts and traditional Indian medical authorities place it at the pinnacle of their pharmacopeia. The bark, leaves, flowers, seeds and fruit pulp are used to treat a wide range of diseases and complaints ranging from leprosy and diabetes to ulcers, skin disorders and constipation. Neem twigs are used by millions of Indians as an antiseptic tooth brush. Its oil is used in the preparation of toothpaste and soap.

The Upavanavinod, an ancient Sanskrit treatise dealing with forestry and agriculture, cites neem as a cure for ailing soils, plants and livestock. Neem cake, the residue from the seeds after oil extraction, is fed to livestock and poultry, while its leaves increase soil fertility. Most importantly, neem is a potent insecticide, effective against about 200 insects, including locusts, brown plant-hoppers, nematodes, mosquito larvae, Colorado beetles and boll weevils. These properties, and others, known to Indians for millennia, have led to the tree's being called in Sanskrit Sarva Roga Nivarini, the curer of all ailments. It is an excellent shady tree and refreshes body and mind.

Coming to the religious front, it is considered as the dwelling place of Sheetla Mata and is venerated by Hindus. It is valued in Islam too. In 'Sharh-e-Mufridat Al-Qanoon', neem has been named as '**Shajar-e-Mubarak**', 'the blessed tree', because of its highly beneficial properties.

According to the existing practice, neem is raised by seeds. The seeds are sown in July immediately after their ripening as they have intermediate viability. As per the practice, the seeds are sown in discarded polybags. The plants raised in these poly bags are transferred in bigger containers in February next year. Any amount of nutrients may be applied but the plants will not attain height more than four feet.

A technique has been developed to raise neem plants of over six feet height. According to this technique, the seeds are sown in nursery beds of 10m x1m in July at a spacing of 2 inches apart.

The plants can be spaced at 4 inches apart in first week of September. Manures and fertilizers have to be applied as per the need. However, one time soil application of balanced doze of nutrients at the time of preparation of nursery beds is sufficient. Later on foliar application of micronutrients at fortnightly interval yields excellent results.

The plants in the beds have to be protected from frost during winters and therefore, airtight temporary polythene tunnels have to be made. The polythene tunnels are removed during the first week of February depending upon the prevailing frost threat conditions. Thereafter, the plants are uprooted and root-shoot cuttings are made. The size of the root-shoot cuttings has to be according to the size of the container. Such cuttings are planted in containers containing soil and nutrient mixture in desired proportions. In bigger containers, there have not to be more than two bags in one row. The foliar application of micronutrients at fortnightly interval has to be followed as a matter of routine. The height of the plants can be anything between 6 feet to 8 feet within a period of five months.

2. Survey and identification of germplasm of Haritiki (*Terminalia chebula*)

Haritiki or Harar has been given the status of mother in Ayurveda. You name any disease and Harar is there to cure it. And you go to any Vaid Ji and the “Purhia” that he gives to you invariably contains a “Chutaki” of Harar. Haritiki has been prominently mentioned in Charak Samhita.

Talking in scientific terms, Haritiki is an excellent stomach and colon cleanser. Its cleansing properties come from four active principles namely Chebulic Acid, Gallic Acid, Chebulinic Acid and Anthraquinones. The purgative properties of Harar mainly come from Anthraquinones. However, excessive use of Harar is to be avoided.

Ayurveda mentions eight varieties of Harar and all varieties can not be used for all diseases. The varieties and their brief description is given below:

1. Vijaya: Oval shape, general purpose use
2. Rohini: Round spherical shape used for ulcers and topical use on wounds
3. Putana: Small very hard, used for topical application as a plaster
4. Amrita: Thick rind, used for purification
5. Abhya: Lines on the surface: Eye wash
6. Jivanti: Gold color, General pupose
7. Chetaki White: Have lines on the surface, used for purgation
8. Chetaki Black: Have lines on the surface, used for purgation

Further, the berries are categorized based on maturity

1. Small berries, unripe fruit

2. Yellow berries, adult fruit

3. Large berry, fully mature fruit.

Large Vijaya is a preferred berry for Triphala

In 2012, survey was conducted for the regeneration status of Harar in govt. forests and private lands in Morni and Kalesar area of Haryana where it grows naturally. The total number of trees was actually counted on the spot with the help of the local people and the staff members. The total number of trees found in Haryana are as under:

No. of trees of Harar existing in Shiwalik belt of Haryana			
S.No.	Name of village	District	Estimated no. of trees
1	Mandhana	Panchkula	500
2	Raji Tikri	Panchkula	600
3	Thandog	Panchkula	50
4.	Hathiya	Panchkula	500
5.	Shiwalik Forest (Govt. forest)	Panchkula & Yamunanagar	500
Total number of trees (Approximately)			2150

During survey it was found that less than 20 percent of Harar trees exist in govt. Forest. The cause of worry is that there are only old trees in the forest. The entire area has been invaded by *Lanata*, *Eupatorium* and *Gallinsoga*. Hence, practically there is no regeneration in govt. forest. It can be seen from the table above that most of Harar plants are on private lands. The reason for this is that the trees are planted by the farmers and are looked after by them properly. They can also perform budding on it. Sale of Harar is a flourishing business in these villages.

The aim of survey was simply to gather the information about the regeneration status of this species. However, it was found that there is a huge genetic variability in the genotypes of this species in Haryana Shiwaliks and areas bordering Himachal. Samples were collected individually for each genotype. Haryana has country's richest germplasm of Harar. It is surprising that no effort had been made in the past to identify this rich genetic heritage that the nature has gifted to us. Except Ketaki Black, all other varieties of Harar exist in Haryana, these varieties should be conserved at all costs. These varieties need to be studied for their propagation behaviour. Accordingly they are urgently required to be put at one place for

creating germplasm and future conservation and improvement. It has been noticed during the survey that some of the varieties are very very rare.

Moving ahead in terms of scientific investigations in Harar, it may be called as the “Mallayika” of Ayurveda, however, the fact is that many scientific studies are yet to be conducted on it. As mentioned above, the medicinal properties of it depend upon the content of chemical constituents. Accordingly its product has to be valued. It is still not known as to how much is the content of Chebulic Acid, Gallic Acid, Chebulinic Acid and Anthraquinones in each variety of Harar. Such an investigation will go a long way in curing ailments for human welfare.

Value addition to Harar fruits is an area where local farmers can earn lot of profit. Carefully harvested fruits if processed scientifically, can fetch good price in the market. The finally processed large fruit should have golden colour. Technique for its fine processing has been developed. Such finely processed Harar can fetch price anything from 2500 to 3000 rupees per kg fruits in international market.

3. Frost studies on semi arid species

As the role of forest manager has been constantly shifting from timber manager to the saviour of ecological security, we have to explore more and more species and restore biodiversity. For this purpose all aspects related to lesser known tree species like seed weight, germination, viability and response to frost etc. have to be studied. Accordingly, the following species were taken up for studying the effect of frost on them:

S.No.	Local Name	Common Name	Scientific Name
1	Paras Peepal	Portia Tree	<i>Thespesia populnea</i>
2.	Teent	Bare Caper	<i>Capparis deciduas</i>
3.	Lasurha	Asyrian Plum	<i>Cordia dichotoma</i>
4.	Meethi Jaal	Mustard Tree	<i>Salvadora oleoides</i>
5.	Khari Jaal	Miswak	<i>Salvadora persica</i>
6.	Narangi Bahar	Jewel’s String	<i>Millettia ovalifolia</i>

It was found that plants mentioned at serial number 1, 2 and 3 were severely affected by frost. Plants mentioned at serial number 5 & 6 were moderately affected. Interesting thing to note is that *S. oleoides* was found to be frost resistant. However, *S. persica* is moderately affected. It was also found that frost effect is followed by twig blight. Accordingly, upon the return of favourable conditions, the shoots emerged from the ground level. The lesson learnt is that all plants as mentioned above except Jaal need to be covered during winters for prevention against the frost.

4. Studies on introduction of *Saraca indica* and *Pterocarpus santalinus*:

Introduction of new species to new habitats is an age old tradition. Some of such species have become the backbone of our economy and are serving the humanity. Almost all of our agriculture crops are introduced species. The species introduction takes place from religious, economic and ecological considerations. It is with this view that Red Sander and Sita Ashok were introduced in Haryana in 2011.

Need not to say that Red sander (*Pterocarpus santalinus*) is valued for dye and wood. Wood is sold at very high price (1000 rupees per Kg). Sita Ashok is highly endangered plant and is religious to Hindus and Budhists.

Red Sander is endemic to Tirupati and Kadappa district of Andhra Pradesh. The seeds of Red Sander were procured from DFO Tirupati. The seed was sown in Karnal and Pinjore in April 2011. All practices as suggested by DFO Tirupati for growing Red Sander in nursery were followed. It was found that the germination was around one percent only. So, it seems that Red Sander can not be grown in Haryana. However, it needs to be tested one more time before finally saying no to it.

Sita Ashok though is seen in parks and gardens. However, its plantation has never been done in forest areas. Owing to its religious, ornamental and ecological value, this species was grown in our nurseries at Pinjore and thereafter, it was planted in Shiwaliks. As regards nursery studies, it was observed that Sita Ashok is not affected by frost. However, towards the end of winter, it was observed that about ten percent of the leaves are affected by leaf blight disease. Hot winds do affect the leaves to some extent but they do not kill the plant.

Its plantation was done in Shiwalik foothills near Pinjore in 2011. The soil profile is of typical Shiwalik character. The soil depth is six inches or so with conglomerates and sandstone down below. In spite of our best efforts, it failed to grow. Hence, it can be concluded that Sita Ashok can not be grown in Shiwalik. However, it can be grown in areas where soil depth is sufficient and moisture is not a problem.

5. Studies on alternatives to *Eucalyptus*

As part of species introduction and finding suitable alternatives to Eucalyptus, Burma Dek (*Melia dubia*) was planted in Naraingarh, Jhumpa and Hisar. It was found that it comes up very well in area where soil depth is good and soil does not remain dry for a very long period. However, it does not tolerate soils above pH 8.5.

It does not tolerate water logging and just struggles in sandy areas. Though it is frost tolerant but hot wind (Loo) kills the top portion leading to deformed stem. It does not have branchiness. It was also observed that Rhesus macaque (*Macaca mulatta*) and Blue Bull (*Boselaphus tragocamellus*) badly damage the plant by breaking the branches.

If the plants are protected well, *M. dubia* is an excellent species for diversification of species for agroforestry and also as suitable alternative to *Eucalyptus*.

6. Rooting of stem cuttings of Sissoo

Shisham continues to be number one timber species of Haryana. In Haryana it is raised through root shoot cuttings. However, for this purpose after preparing the root shoot cuttings, the rest of the plant material is discarded. The possibility of using the discarded stem portion for raising plants was explored.

IBA (Indole Butyric Acid) was applied at strength varying from 500 PPM to 3000PPM to the stem and root portion. It is concluded that the percentage of rooted cuttings in the case of root portion is around 90 percent.

Similarly, in the case of 2nd, 3rd, 4th, 5th and 6th cutting, the rooting percentage was 86, 82, 75, 72 and 66 percent respectively. It can be concluded that with application of IBA at 500 PPM stem portion which otherwise goes waste can be utilized for growing plants. It was also found that even without application of IBA the root portion and second cutting can be rooted to about 75 percent success rate. Hence, it should be adopted in the department without any doubt as the results have been repeatedly confirmed for three years.

7. Nursery Evaluation of Poplar clones

With a view to maintain germplasm bank for poplar, the genetic material was procured from all over the country. Dr. Ramesh Dhiman, GM of WIMCO and Dr. Salil Tiwari of G.B. Pant University of Agricultural Sciences and Technology were kind enough to make us available the entire poplar genetic material available with them. This germplasm was planted at Shekhupura and the same was evaluated at nursery stage.

The genetic material comprised of the following clones: WSL, G-48, L-200, L-84, Kranti, Bahar, FRIAM : 1, 2, 9, 15, 20, 21, 22, 32, 34, 35, 37, 40, 44, 46, 49, 57, 58, 61, 64, 65, 66, 70, 72, 74, 77, 80, 81, 83, 90, 97, 100, 103, 107, 111, 113, 118, 132, 140, 142, 172, FRIFS-15, 41, 57, 76, 117, 121, 138, 157, 170, 211, 217, **SC series** : S-7C-5, S-7C-15, S-7C-4, S-7C-20, 15, 41, 57, 76, 117, 121, 138, 157, 170, 211 and 217.

For the purpose of evaluation, girth and height of the plants were considered for this purpose. Out of 56 clones evaluated, ten most promising clones were ranked as under: WSL-22, L200/84, FRI AM 65, PP-5, G 48+FRI FS 48, FRI AM 132, FRI AM 46, FRI AM 111, Kranti & FRI AM 74.

7. Survey for adoption of poplar clones

The field house hold survey was conducted to know as to what is the trend of adoption of different clones of poplar in the state. This will guide us in future planning when it comes to proportion of each clone to be raised in the nursery. The results of the survey are given as under:

- G-48: Still rules poplar world inspite of all problems associated with it. We found that G-48 still occupies about 60 percent of total poplar planted in Haryana.
- WSL-22: Suited for growing along river banks where there is predominance of sand. In spite of its good biomass production, it has not been able to beat G-48.
- S7 C15: Biomass production is high. However, it is not liked by the industries due to the *yellow colour* of the wood. Hence, it has almost vanished from the field and the market. Wood is resistant to natural decay.
- S7C8: Its biomass production is high. However, it has failed to stay in Haryana as farmers do not like it due to the large size of the leaves.
- KRANTI: It may be a name among the poplar breeders and officers and officials of forest department, but people do not know much about it.
- UDAI: Suitable for growing in high water table areas. Can also tolerate stagnated water for some time. Its wood is also good quality and the colour of its wood matches with that of G-48. Hence, it is the second choice of the farmers and industries after G-48.
- WSL-32: It is particularly suitable for dark and high pH soils. Also suitable for growing in clayey soils having low organic matter which crack open after they dry up. Its wood is also good and is not disliked. Its weight is highest among all poplar clones being grown in Haryana.

8. Standardization of nursery techniques for growing Tint/Bare Caper (*Capparis decidua*)

Bare Caper is an inseparable part of semi arid ecosystem. Besides being a very good habitat for sparrows, it is source of nectar for honey bees. It has become endangered species as its fruits are harvested immature.

For the last three years, efforts have been made to standardize nurseries raising techniques of this plant. The plants were maintained upto December, it was tried to protect them from frost by keeping them in airtight polythene tunnels. Plants were also put in raised nursery beds. However, the plants died during January.

Efforts are on to know as to what is cause of mortality of the plants in January.

9. Standardization of nursery techniques for growing Barna/Sun Plant (*Crataeva religiosa*)

The Barna is a multipurpose plant of Haryana. It is religious and is worshipped as representative of Sun God. It is ornamental, excellent shade bearer and excellent source of nectar for honey bees. It is a powerful liver tonic as well.

However, it has been placed in the category of RET species. Therefore, germination and viability studies were conducted on this species. Nursery techniques have been standardized for raising this species. Its fruits were collected from area around Pinjore in July 2011. It was found that one kg contains about 74 fruits. One fruit contains 34 seeds and there are 2919 seeds in one kg. The seeds remain viable for one month. The germination starts after 7 days and is completed within 25 days. The germination percentage varies from 60 to 70 percent.

In nursery the seeds after removing the pulp were sown after one week of seed collection. It was observed that this is a slow growing species. After one year it could attain a height of only one foot. It was also observed that Blue Pumpkin Beetle (*Aucolophora sp.*) is serious pest of Barna.

It completely defoliates the plant and even devours the growing tips as well. The pest attacks the plant during rainy season and remains active till November when the host sheds its leaves. The pest was however, controlled by spraying Rogor OP insecticide at 0.01 percent.

10. Germination studies on Pula (*Kydia calycina*)

Pula is another LKTS which has been placed in the category of RET species. It is source of fodder during scarcity and source of fuelwood though not of very high calorific value. It is an outstanding source of nectar for honey bees. One can see thousands of honey bees on it during March and September. It is a RET species because its natural regeneration is not taking place in areas where it grows naturally.

As no attempts have been made in the past to regenerate this species artificially, seeds were collected from two locations. Seeds were brought from Palampur and also collected from Morni area. It was found that there are 651 flowers in 25 grams on dry matter basis. It was also found that there are 858 seeds in 10 gram weight.

Pula seed germination was attempted in germination chambers and polythene bags in the nursery. The seed being very small, sand was mixed with it. But no success could be achieved in germinating the seed. Seed samples were sent to Seed Division, FRI Dehradun. Dr. Manisha Thapliyal of Seed Division FRI conducted seed germination studies on it under controlled conditions. She reported that the germination of Haryana seed was 1 to 2 percent and that of

Himachal seed was 4 to 5 percent. The viability studies could not be done because it is a long process and not possible for FRI to do so.

a. Performance of Salt Wattle (*Acacia ampliceps*) in salt affected soils Salt

Wattle is shrub, excellent halophyte and excellent habitat for sparrows and honey bees. It is an evergreen species and good source of fuelwood. It was introduced in the state in 2011. A patch of this species was raised on Hisar- Delhi Road at a place called Mayyar- 12 km from Hisar town where pH is more than 9.5. So far, no plant has been able to grow under the prevailing very high pH conditions.

It was observed that it performs excellently well under high pH conditions and not only so, it is a fast growing species as well. Being evergreen species, it gives soothing look as well.

It can be said that it is a very good substitute for mesquite and can be planted where people refuse to plant mesquite. Further, for creating good habitat for sparrow and honey bees, its mass scale plantations need to be raised in the state.

11. Identification of species for salt affected soils

The state of Haryana has a big chunk of salt affected soils. It needs to be put to best protective and productive use. Though *Prosopis juliflora* is an excellent species for reclaiming these soils but it is not liked by those farmers who do not use it as fuelwood. In such a situation following species were planted:

- *Salvadora persica*
- *Salvadora oleoides*
- *Thespesia populnea*
- *Terminalia arjuna*
- *Milletia pinnata* (*Pongamia pinnata*)
- *Tamarix articulata*
- *Milletia ovalifolia*
- *Prosopis pallida*

It was found that except Arjun, *P. pallida* and *Milletia ovalifolia*, all others are performing very well. It was also observed that *Thespesia* and both species of *Salvadora* perform excellently well under very high pH (>9.5) conditions.

12. Depth of *Eucalyptus* roots in relation to water uptake

One of the controversies associated with *Eucalyptus* is that it sucks lot of water from the soil and as a result of that, the water table has gone down. It is another issue that many crop plants like paddy and many trees need more water for production of biomass on per unit basis. Any plant or tree can suck more water from the soil if its roots are in close contact with water. The study was conducted in Bithmara to know the depth of roots of various clones and to correlate the depth of each with water intake. The trees of various clones felled at Bithmara in 2012 were used for the purpose of the study. The following clones were planted: 1, 3, 4, 6, 7, 8, 9, 27, 71, 88, 99, 105, 115, 116, 119, 128, 130, 132, 142, 147, 157, 271 and 277. The depth of the roots of these plants varied from 236 cms to 309 cms.

The root depth of four most promising clones which ranked best as per our analysis is as under:

S.No.	Number of clone	Depth in cm	Age of clonal plantation
1	132	304	14 years
2	105	290	14 years
3	83	306	14 years
4	147	240	14 years

It is evident from the above description that the range of root depth varies from 236 cms to 309 cms. The water table in Bithmara is at 30 to 40 meters. So, how can *Eucalyptus* be blamed for lowering water table?

13. Evaluation of clones against *Eucalyptus* Gall Wasp (*Leptocybe invasa*)

This pest does not need any introduction and we all know by now about it. Nowadays, it is down but not out. So, we should not take it for granted that the problem is over. It has been noticed that there was a severe attack at number of places this year as well.

Research Wing has screened germplasm for *Eucalyptus* and accordingly the genotypes showing tolerance to this pest have been suggested. Research Wing has also worked on the long term strategy to be followed in case the pest returns with severe attack.

The germplasm of *Eucalyptus* available with Haryana Forest Department was evaluated at Seonthi and Bithmara for tolerance/resistance against this pest. The germplasm for the screening included the following: 3, 7, 10, 52, 71, 83, 99, 105, 130, 271, 286 and 290 3, 4, 6, 7, 8, 9, 10, 27, 71, 83, 99, 105, 115, 116, 119, 128, 130, 132, 142, 147, 157, 271 and 277 84,99,134,159,161, 265,266,269, 272,273, 286,290 316(FRI) 413 (FRI),526, 2070 JKSC5, JKSC2, JKSC2N, JKSC4, JKSC8, JKSC11 of Raigarh (Orissa) and *Corymbia* hybrids.

It was found that no plant of seed or clonal origin could resist the attack of *Leptocybe invasa*. However, Bhadrachalam clone no. 288 was least attacked. Similarly clone no. 10 showed least resistance to the pest. In fact clone no. 10 was very badly attacked. Accordingly *Eucalyptus* clones which can be planted in the event of severe attack by this pest are: 288,7 & 130. It is worth mentioning here that clone no. 288 is best among all other clones as regards to the shape of the stem, straightness, appearance, wind effect, tolerance to pest and diseases.

Coming to *Corymbia* hybrids, it would be appropriate to mention here that recently *Eucalyptus citriodora* and *E. torelliana* have been given the status of separate genera. These species have tomentose on their leaves. These tomentose which act as sharp needles prevent physical contact between the ovipositor of Gall Wasp and the soft tissue of the plant. Hence, the plants of *Corymbia* are not attacked by Gall Wasp. A Genotype of *Corymbia* hybrids which is not attacked by Gall Wasp has been identified, it has been tested for its end uses also. This genotype has also been tested for drying properties and furniture making. Attractive furniture has been made out of its wood.

It takes attractive polish and the wood is excellent creamy white. Accordingly, we are propagating this genotype in our mist chambers. Protocol for its multiplication by tissue is almost ready

14. Evaluation of Eucalyptus germplasm against Witches Broom Disease

Little Leaf disease was first reported in India in 1964 but was not reported from Haryana. This disease was first reported from Bithmara research plot in 2010 in mature plants of clonal germplasm. Thereafter, almost 100% plants of *Eucalyptus* in nurseries are being attacked by this disease.

This is also called Spike Disease or in very simple words Little Leaf Disease. This disease is caused by Phytoplasmas formerly known as Mycoplasmas like Organisms (MLOs). The disease is said to be transmitted by Eriophid Mite & Western Flower Thrip (*Franklinella occidentalis*).

During the process of sucking of the sap from the tender shoots or flowers, the pathogen is transmitted to the plant system. It reaches the plant transport mechanism i.e. the xylem and phloem vessels. Slowly and steadily, the movement of sap and nutrients within the plant system is blocked. As a result of this, the size of the leaves is reduced considerably. The plant dies after three or four years.

The peculiarity of this pest is that it attacks plants of all ages. Hence, even the old and mature plants are also killed contrary to *Leptocybe invasa* which damages the plants in the nursery and young plantations upto the age of three years.

Once the pest enters the plant system, there is no way to control it and the plant ultimately dies. The prophylactic control measures have to be followed since the beginning and at regular intervals even before the symptoms appear.

As precautionary measure 0.01 percent solution of Rogor or any other systemic organophosphate insecticide should be sprayed at fortnightly interval. There is no control once the pest has succeeded in entering the plant system.

15. Curling and Puckering Disease of *Terminalias*

This disease was first of all noticed on *Terminalia arjuna* in 2010 during rainy season.

The Arjuna or *Terminalia arjuna* has mythological and medicinal significance. Named after Arjuna of Mahabharata, this tree is a source of heart protectants like Ubiquinone (CoQ10). No serious insect, pest or fungus was noticed on Arjun in Haryana till 2010. During 2010 and 2011, three pests badly affected Arjun plants of all ages in nurseries, plantations and in parks and gardens of Haryana. These pests are: The Gall Insect, Leaf Miner and Curling and Puckering disease of leaves. Curling and Puckering symptom of Arjun leaves was first time found in the nurseries and fully grown trees in the year 2011.

16. To find out suitable spacing for planting poplar in nursery

During Feb 2012, a total of 28 clones of WIMCO, FRI & Pantnagar were planted in Shekhupura (Karnal). The clones are: WIMCO-27, WIMCO-32, WIMCO-37, WIMCO-39, WIMCO-62, WIMCO-A/26, WIMCO-A/49, WIMCO-106, WSL-22, Bahar, WIMCO-12, PP-5, FRIAM-1, 37, 70, 72,81,100,107,118, L-12,19,23,S7C4, S7C8, S7C15,S7C20 & D-121. All clones were planted in three replications at three different spacing's comprising of 30cmx30cms, of 30cmx40cms and of 30cmx45cms. The plants were looked after very well. It was found that plants attained plantable size in all treatments. However, it was concluded that the plants planted at of 30cmx45cms spacing yield best results.

17. Leaf and Twig Blight of *Eucalyptus*:

This disease is caused by a fungus called *Cylindrocladium quinqueseptatum*. This is basically a disease of monsoon season and is particularly serious in nurseries. However, it also attacks plants of all ages. The symptoms of the disease start appearing in the form of reddish brown lesions which turn black and within three or four days they cover the whole leaf surface. Thereafter, the leaves turn blackish brown and appear as if they are rotten. Severely infested plant dies within fortnight.

There is no effective control of the disease as such. However, Propiconazole/ Dithane M-54 @ 0.2 percent in water solution can give some protection from the pest. The fallen leaves have to be collected and are either to be buried or burnt to prevent the air borne spores from spreading in the air.

18. Gummosis of Eucalyptus:

This disease has been noticed in northern parts of Haryana. In this case blood like sap oozes from the infested plant. It is particularly a problem of grown up trees and tree dies after some time. It is not very serious at present and Research Wing may be contacted in case of severe problem.

19. Nursery and field studies on Jaal/Peelu (*Salvadora oleoides*)

There is no doubt that Jaal is life of people of Haryana. You can not expect a Joharh without Jaal, hot summers without juicy and sweet peels, village elders enjoying the soota (puffs) of Hukkah without the shade of Jaal, and a lively bani producing melodious sound of birds without Jaal. It is a versatile species and an excellent halophyte.

While its twigs make an excellent tooth brush, it is good fodder for camel, rabbit and habitat for Golden Flame Backed Wood Pecker and parakeets. The species is not regenerating because the seed setting has become rare. Accordingly, IUCN has placed Jaal in the category of RET species. This fact can not be ignored that Jaal is the flagship & umbrella species of Haryana.

As no information is available on this species, A number of studies were conducted on this species related to its germination, viability, effect of manures and fertilizers and possibility of raising tall plants.

The year 2010 happened to be a very good year for Jaal as it set seeds after a long gap. This opportunity was utilized and following studies were conducted:

- Seed germination
- Seed weight
- Seed viability
- Growth enhancement studies like effect of manures and fertilizers.
- Raising tall plants by root shoot cuttings.
- Effect of root hormones on rooting and growth

Material and Method:

- Seeds were collected from three different locations viz. Bir Hisar, Mahendergarh and Rajgarh.
- Some seeds were depulped and thereafter dried in shade for a week.
- Seed Weight: Sun dried seeds were weighed.

Germination study:

- Two hundred shade dried seeds were sown in two germination trays separately. Also two hundred fresh seeds with pulp intact were sown in two germination trays separately at room temperature (27° C).

Seed storage and viability studies:

- The seeds were stored at room temperature
- Seed viability study was conducted in germination chambers of Forest Seed Testing Laboratory Pinjore.
- One hundred seeds were sown separately in two germination trays at an interval of seven days and the number of seeds germinated was counted.
- This process continued till the germination dropped to 20 percent.

Study on raising tall seedlings of Jaal:

- The study was conducted at Bithmara in Hisar district.
- The seeds were sown directly in the nursery beds of size 10mx1m in the month of June, 2010.
- The plants were uprooted in the first week of February.

Root shoot cuttings containing 5cm shoot and 10 cm root portion were prepared:

- 400 stumps treated with 500 PPM of IBA were planted in the polybags of size 20cmx30cm.
- 400 stumps treated with 500 PPM of IBA were planted in polybags of size 30cmx45cm.

Control: 400 stumps without IBA treatment were planted in polybags of size 20cmx30cm.

Effect of manures and fertilizers on the growth of Jaal plants:

- Seeds were sown in polybags of size 15cmx22cm in the month of June.
- In the second week of February, 50 plants were planted in bigger Polybags in each treatment.

- **A: DAP treatment:**

- Gunny bag of size 30cm x 45cm were filled with 50 gm of DAP thoroughly mixed with local soil. In 50 gunny bags one Jaal plant was planted in each bag.

B: Farm Yard Manure (FYM) Treatment:

50 gunny bags of size 30cm x 45cm were filled with one kg of FYM thoroughly mixed with local soil and plants were planted.

C: Urea treatment:

- **50 plants were planted in gunny bags** of size 30cm x 45cm containing standard soil mixture and 50 gram of urea in it.

- **D: Vermicompost treatment:**

- 50 Gunny bags of size 30cm x 45cm were filled with 500 gm of vermicompost thoroughly mixed with local soil and the plants were planted.

E: Azotobacter treatment

- **50 plants were planted in gunny bags** of size 30cm x 45cm containing local soil and *Azotobacter* in it.
- **Control:**
- 50 gunny bags were filled with local soil.

Results:

- Germination started after 48 hours of sowing of seeds and was completed within 120 hours.
- The germination in seeds with pulp and without pulp was around 90 percent proving that pulp does not inhibit germination inhibitors as is believed.
- There are 34051 seeds in one kg.
- Seeds retain 90 percent viability up to 160 days. However, they became non viable after 170 days.
- Jaal seeds have to be sown in beds or in polybags up to the month of August in the same year.
- Seeds become non-viable by Feb. next.
- The sowing cannot be delayed beyond August.

As regards growth enhancement studies, following results were obtained:

Height of Jaal (<i>Salvadora oleoides</i>) plants recorded in response to manures and fertilizer treatment			
S.No.	Treatment	Maximum Height (Cm)	Average Height (Cm)

1	FYM	99	54.54
2	Urea	72	50.94
3	Vermicompost	70	50.32
4	DAP	88	50.04
5	<i>Azotobacter</i>	76	46.94

Results of root shoot cuttings:

- The sprouting of cuttings started after one month.
- Irrespective of the size of the container only ten percent cuttings sprouted.
- Only 5 percent cuttings rooted & IBA did not help in successfully rooting the cuttings
- Plants became bushy and did not put good growth. Hence, should not be attempted.

Conclusion:

- *S. oleoides* is becoming endangered due to non setting of seeds.
- Once there is good seed setting, germination is not a problem.
- Root shoot cuttings, do not root. Hence, should not be attempted.
- Organic manures are the best growth enhancers.

- **Propagation studies on *Cordia gharaf***

Goondani or *Cordia gharaf* is threatened plant of western and southern Haryana. It has food and medicinal value besides ecology value. The leaves are a potent cure against mouth ulcers. This plant has been successfully propagated and the seedlings have been maintained. The seeds were sown in June. About 1000 seedlings of this species were raised.

However, there was mass mortality and by the end of February only about fifty plants could be saved. The cause of mortality is still not known. The efforts are on.

- **Propagation studies on Frankincense (*Boswellia serrata*)**

It is a RET species of Shiwaliks and Aravallis. As seed setting is very inadequate, air layering, stem cutting and tissue culture were tried. However, success could not be achieved. The efforts are on.

- **Propagation studies on Desert Date (*Balanites aegyptica*)** Commonly called Hingot, Desert Date has traditional, industrial and ecological value. This species grows in western and southern Haryana and has been placed in threatened category. This species has been successfully propagated.

Thar Shobha introduced Jand (*Prosopis cineraria*) is crowned with Kalptaru (wish fulfill tree) of desert. Agricultural crops can be easily grown in its association However, it is a slow growing species. Its fast growing selection has been recently introduced. Its performance is under watch.

- **Leaf Miner Insect of *Milletia pinnata* identified**

It is well known fact that *Pongamia pinnata* new name *Millettia pinnata* is an important shady tree and is planted along roads and in parks & gardens for shade. It is a good halophyte as well. However, a miner insect is harming its ornamental value as affected trees look ugly.

The causal insect has been identified as *Asphondylia pongamiae*. It is Cecidomyd Dipteran insect. Research is on for identifying the resistant genotypes.

- **Gall Insect of Devil Tree identified**

Saptarni/Scholar/Devil Tree is an important shady tree and is planted along roads and in parks & gardens for shade. However, a gall forming insect is harming its ornamental value as affected trees look ugly. People have left planting it because of the insect attack. The causal insect has been identified as *Pauropsylla tuberculata*. It is a Psyllid Homopteran insect. The control of this pest is being looked for.

- **A plant that breaks rocks**

A plant which penetrates the rocks has been recently identified. It is an excellent halophyte and is suitable for planting in soils having Kankar pan.

The plant is none other than Kapok or *Cochlospermum mopane*. This plant has been introduced and few hundred plants of this species are available in research nurseries.

- **Tasted Limited Success**

In view of global shift in role of foresters from mere timber managers to the saviours of ecological security, we are emphasizing on conservation of forest ecosystem with emphasis on natural regeneration. In this context a religious and ornamental tree called Krishna's Butter Cup. (*Ficus benghalensis krishaniae*) was tried to propagate. The legend is that Lord Krishna ate butter in the leaves of this tree. It is highly endangered plant and is rarely seen except in botanical gardens.

We tried to raise it by seeds but we failed. We tried stem cutting but we had two percent success. However, we have succeeded in raising thirty plants of it and we have planted in our ficatum.

- ***Ficus* raised in beds**

Ficus are life nourishing trees and ecological value of *Ficus* need not to be discussed here. If *Ficus* plants are raised by stem cuttings, they do not give good look. If its plants are raised by seed, they not only look healthy but also attractive. However, common notion is that *Ficus* seeds will not germinate until and unless they pass through the gut of the birds.

However, this notion has been broken. *Ficus* plants have been successfully raised in our nursery beds by giving special seed treatments.

- **Burma Dek raised by root shoot and stem cuttings**

Melia has been successfully raised by root shoot and stem cuttings. It has been concluded that success is good in case of root shoot cuttings and first stem cutting also roots but growth of stem cuttings is far less than that of root shoot cuttings. It was also

found that the plants of root shoot are far better than the ones raised through stem cuttings. Hence, *Melia* should be raised by root shoot cuttings.

- **ETP planting attempted in *Melia dubia***

Owing to the overwhelming success of *Melia dubia* in the state, there is no doubt left that this species will be a leading species in agroforestry. In view of this its ETP planting was done with and without earth ball. It was concluded that there is 100 percent success in the case of earth ball planting but only 15 percent in the case of naked root planting. This study will be repeated in January next year. We learn from our mistakes and will try to rectify them, before finally reaching at conclusion whether naked root planting should also be attempted or not.

- **Plastic Mulch in forest nurseries**

The feasibility of using plastic mulch in forestry was studied. The idea was to compare the growth of the plants using plastic mulch with the traditional method where no plastic mulch was used.

For this purpose polythene of different microns was used for growing Eucalyptus and Poplar in them. The record of weeding, hoeings and watering in both the cases was maintained, and growth and expenditure was compared. It was found that in the case of plastic mulch the water requirement of the plants comes down by about 30 percent. No weeding and hoeing is required in this case. It is, therefore, concluded that the growth in the case of plastic mulch is about ten percent higher than the normal conditions. The higher growth in the case of plastic mulch can be attributed to keeping soil warm during early period of the growth especially when the night temperature is low.

As regards per unit cost of raising plants it was found that there is no significant difference between the plastic mulch and traditional plant raising method. The negative feature of this finding was that snakes sneaked into the polythene and labourers were of afraid of entering in the bed. It is recommend that thick polythene has to be used and the sheet should be properly placed on the soil surface failing which the sheet will be lifted and weeds like Nut Sedge (*Cyperus rotundus*) will start creating trouble.