

**National Program for
Conservation and Development of Forest Genetic Resources**

**Pilot Project
(Implemented at FRI, Dehradun)**

On
**Creation of Centre of Excellence on
Forest Genetic Resources (FGR) of India
(CoEFGR)**

**Funded under
Adhoc CAMPA Fund
Ministry of Environment, Forest & Climate Change
(2016 to 2022)**



**Progress Report
(January- March 2021)**

**Submitted by
Forest Research Institute (FRI),
New Forest P.O., Dehradun 248 006**

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1. PROJECT SUMMARY

Title of the Project:	National Program for Conservation and Development of Forest Genetic Resources: Pilot on ‘Creation of Centre of Excellence on Forest Genetic Resources (CoFGR)’ at FRI Dehradun
Funding Agency:	Adhoc CAMPA Fund Ministry of Environment, Forest & Climate Change, Govt. of India
Project Outlay:	Rs. 861.20 lakhs (January 2016 – 31 March 2022)
Project Period:	5 years + 1 year no cost extension
Grants released:	1 st installment - 146.25 lakhs 2 nd installment - 146.25 lakhs 3 rd installment - 245.00 lakhs 4 th installment – 127.05 lakhs 5 th instalment – 109.45 lakhs 6 th installment – 86.35 lakh
Date of release:	1 st installment on 21 st January 2016 2 nd installment on 22 th March 2017 3 rd installment on 17 th Nov 2017 4 th installment on 4 th September 2018 5 th instalment in September 2020 6 th installment in March 2021
Project Executing Authority:	Director Forest Research Institute, Dehradun
Period of present progress report:	Quarterly report (Jan-Mar 2021) Cumulative progress up to 31 st March, 2021

2. PROJECT IMPLEMENTATION TEAM

Project Director	Director FRI
Project Coordinator	Dr. H.S.Ginwal, Scientist G
Project Jurisdiction	Uttarakhand State
Working Groups	Four (detailed below)

A. Documentation Cell/working group

	Investigators	Tasks
A1	Dr. Anup Chandra, Sc. F	Field surveys to document FGR diversity & their population status with GPS referencing [<i>Target = 250 species</i>]
A2	Dr. M. S. Bhandari, Sc. D	Extraction of FGR distribution records from accredited national herbaria (including international herbaria viz. Kew) and from Forest Working Plans [<i>Target = 250 species</i>]
	Dr. Ranjana Negi, Sc. D	
A3	Dr. P.K. Verma, RO	
A4		Preparation of eco-distribution maps of priority FGR species, including orientation and training of project staff. [<i>Target = 50 species</i>]
A5		Modernization and upgradation of FRI Herbarium including digitization of herbarium sheets; and developing herbarium database, & incorporating new accessions to herbarium
A6		Collection of seeds of FGRs from different accessions for long-term storage. Seed of each species to be collected from an average of five provenances/ seed zones. [<i>Target = 90 species</i>]
A7		Collection of germplasm for <i>in vitro</i> storage in the form of tissue/embryo culture. [<i>Target = 10 species</i>]
A8		Collection of pollen for long term preservation [<i>Target = 10 species</i>]
		Conservation of FGR germplasm in FRI arboreta and botanical garden and preparing database of such accessions of all arboreta in Uttarakhand. [<i>Target = 100 species</i>]

B. FGR Seed and Germplasm Storage cell/working group

	Name of Investigators	Tasks
B1	Dr. Manisha Thapliyal, Sc. F	Seed extraction, cleaning, grading, data recording, packing, labeling with passport data, etc. and putting the seeds under medium and long term storage, in collaboration with NBPGR. [<i>Target = 90 species</i>]
	Dr. Ajay Thakur, Sc. F	
B2	Dr. Shambhavi Yadav, Sc. B	Minimum moisture content and periodic seed viability and vigour trials on stored seed along with working out half-life of the seeds in storage, and developing biological models to predict risks associated with seed storage [<i>Target = 20 species</i>]
B3		Developing protocols for storage of FGR germplasm in the form of 'pollens' for red-listed species [<i>Target = 10 species</i>]

B4 Developing protocols for storage of germplasm of FGR species of very high conservation concern and those having recalcitrant seeds *in vitro*, minimal growth cultures and embryo culture [Target = 10 species]

C. FGR Characterization Cell/working group

	Name of Investigators	Tasks
C1	Dr. H.S.Ginwal, Sc. G Dr. Santan Barthwal, Sc. F Dr. V.K. Varshney, Sc. G	Molecular characterization of FGRs, specifically for biochemical traits, and screening for disease and pests. [Target = 5 species]
C2	Dr. Amit Pandey, Sc. G Mr. R.K. Meena, Sc. D	Genetic diversity studies of FGRs of conservation concern and high commercial value with germplasm collected from across the range of distribution of the species. [Target = 5 species]

D. FGR Conservation Cell

	Name of Investigators	Tasks
D1	Dr. Dinesh Kumar, Sc. G Dr. P.S.Rawat, Sc. F	Conservation assessment & management prioritization (CAMP) workshop for assessment of threat status of FGRs of Uttarakhand [Target = 1 Workshops]
D2	Dr. Ramakant, Sc. D	Establishment of Field Gene Banks of priority FGR species. Includes collection of germplasm of selected species from across the country, multiplying and maintaining it in the nursery, site preparation, planting, site protection, and maintenance [Target = 5 species]
D3		Development and standardization of nursery techniques of FGR species of very high conservation concern. [Target = 5 species]
D4		Evaluation of selected PAs for their effectiveness in conserving priority FGRs. Floristic survey & transect studies in the selected PAs to cover different seasons. [Target = 1 PA]
D5		Establishment of FGR Conservation Areas (FGR-CAs) in natural forests for species of high conservation concern. Population studies for selected species [Target = CAs for 5 species]
D6		<i>Circa situm</i> conservation of remnant individuals of important FGRs on lands outside forests. Survey for remnant populations of FGRs on private lands.

3. QUARTERLY PROGRESS REPORT

A brief progress of activities for the period of **January- March 2021** as per the action plan of the project has been summarized in the following points:

A. FGR DOCUMENTATION

i. Upgradation and digitization of DD Herbarium

Digitization of DD Herbarium specimens is under progress. The targeted specimens to be digitized under current quarter were **4234** specimens, **4250** digital images have been entered in to Digital Herbarium Specimen Database.

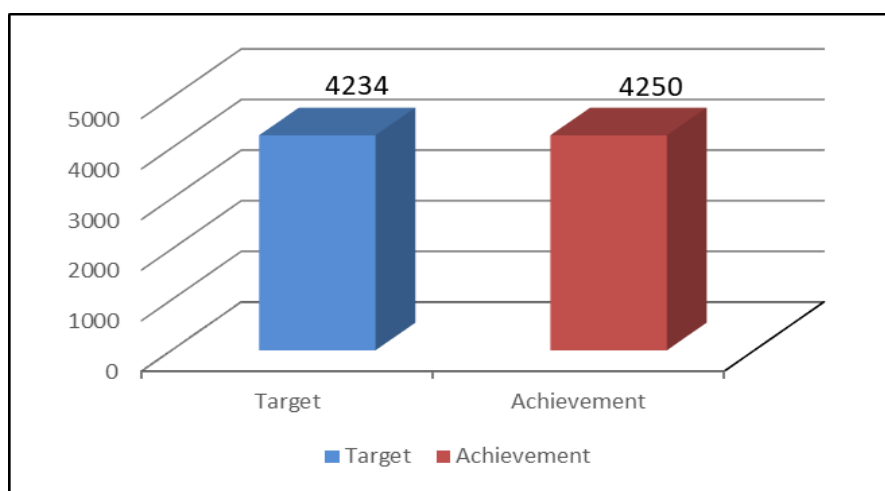


Figure 1: Growth of the DD dataset under current quarter (January to March, 2021)

ii. Documentation of FGR species

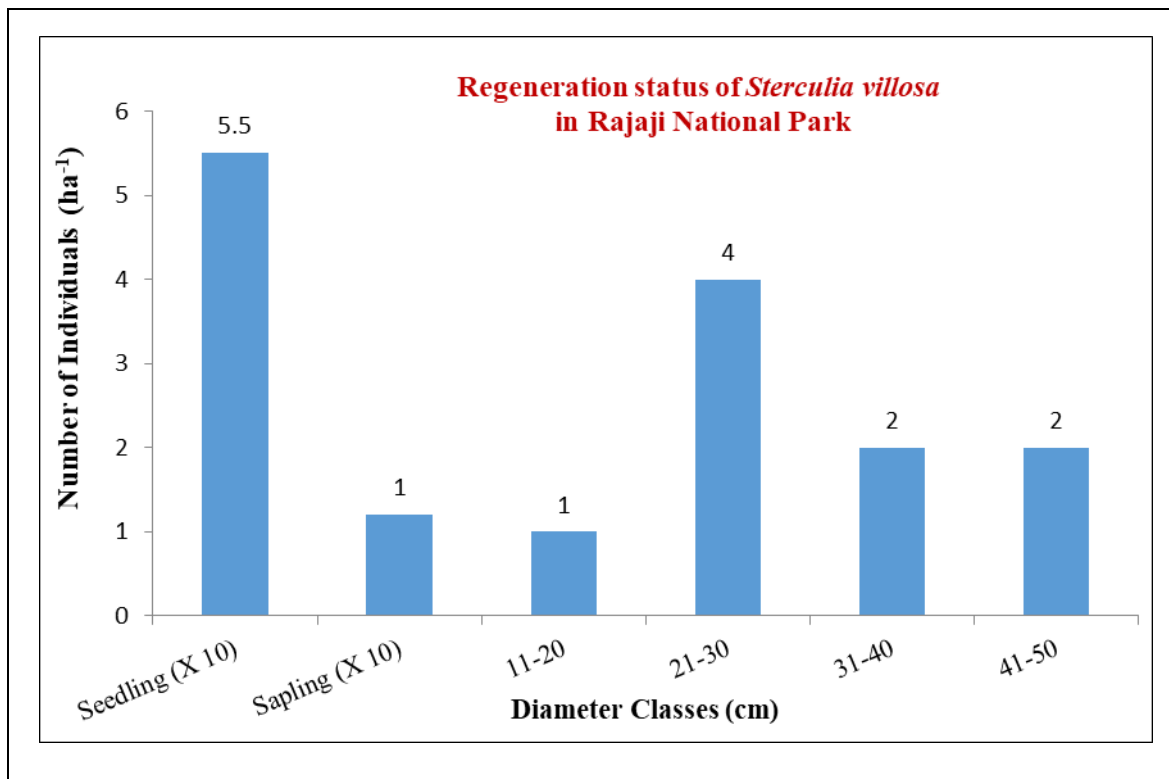
3.1.2.1 Field Survey for distribution

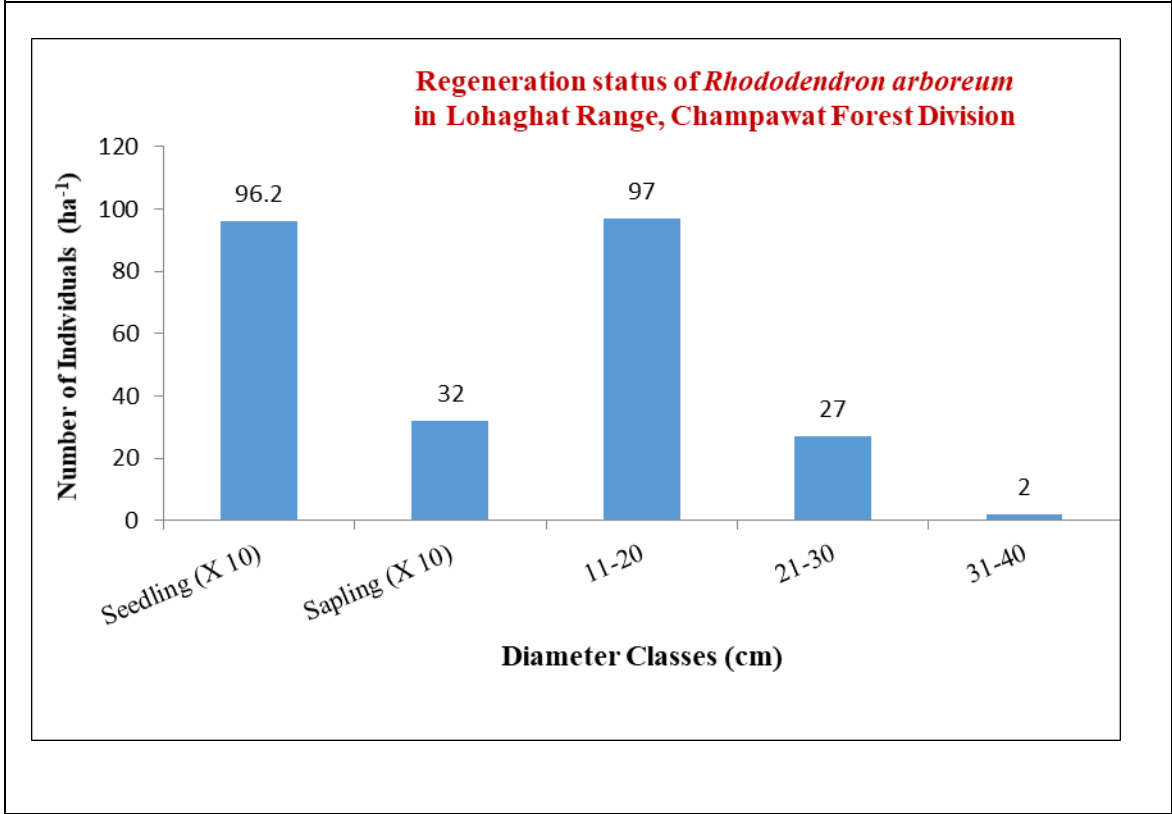
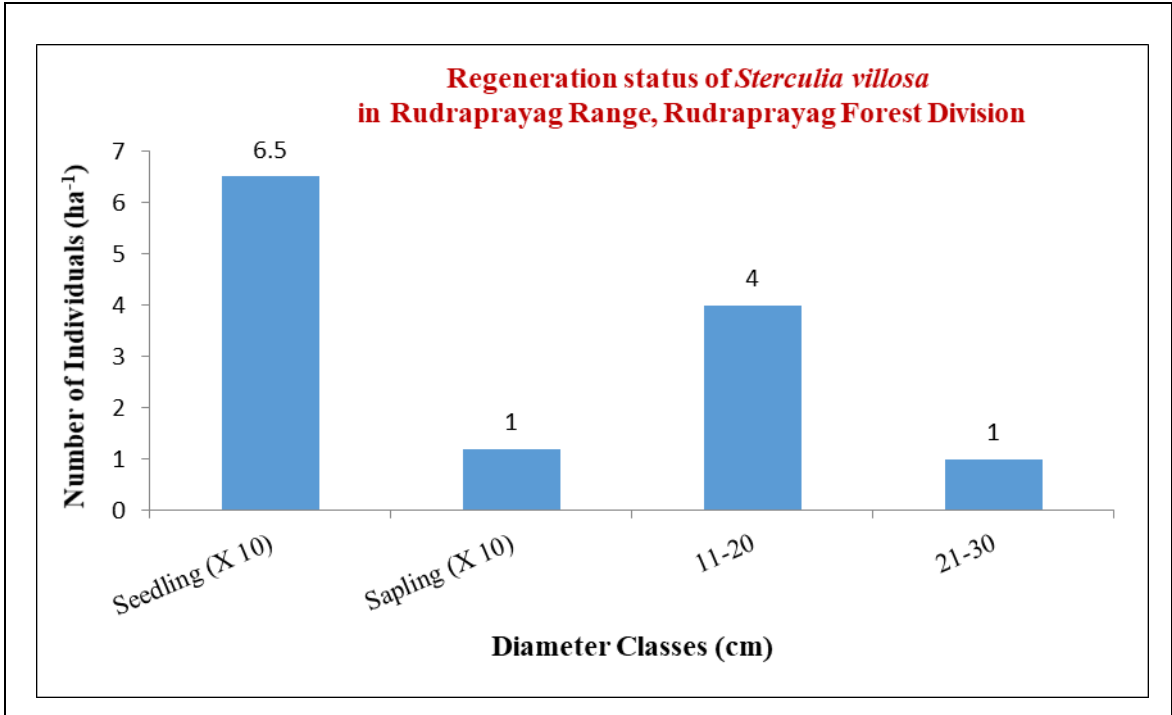
The field surveys as per the target of 250 species have been completed.

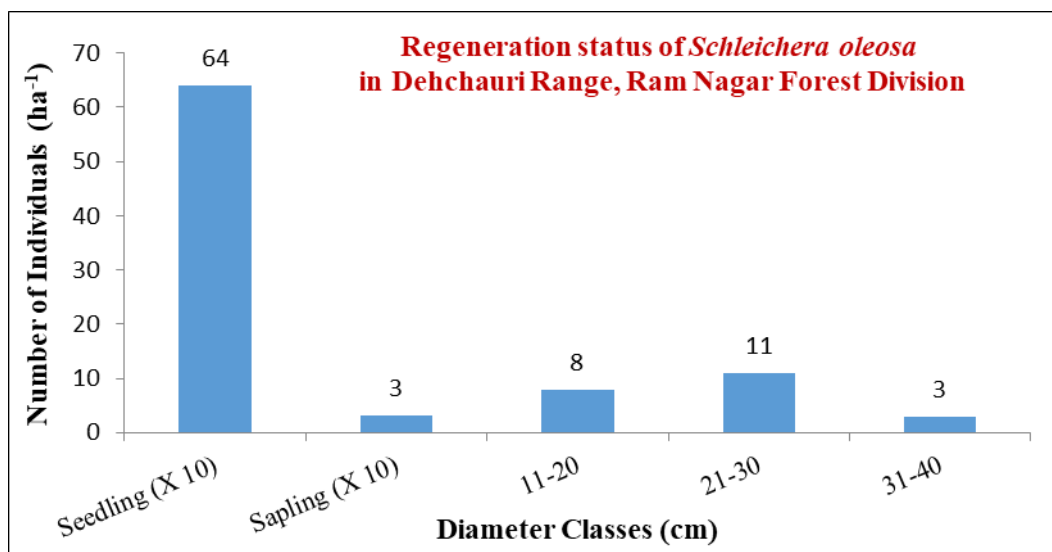
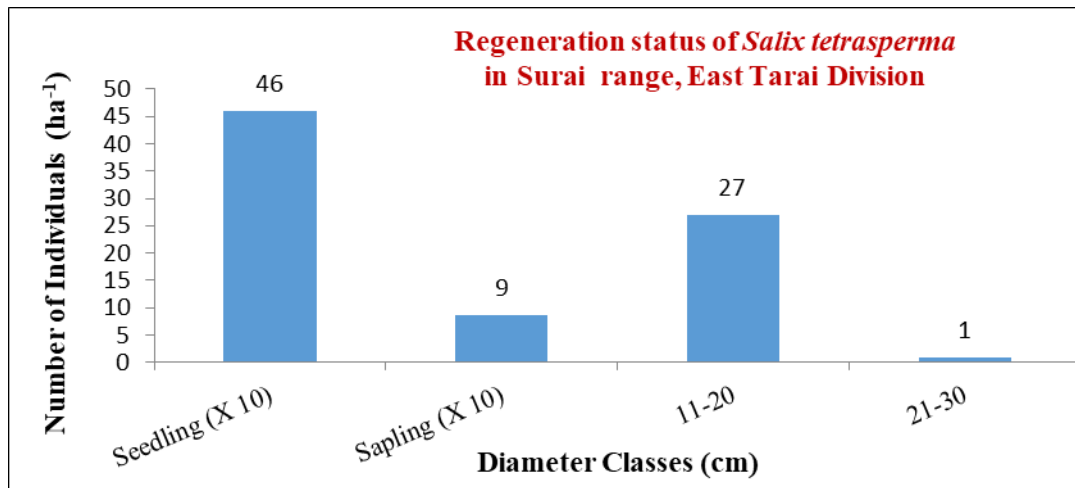
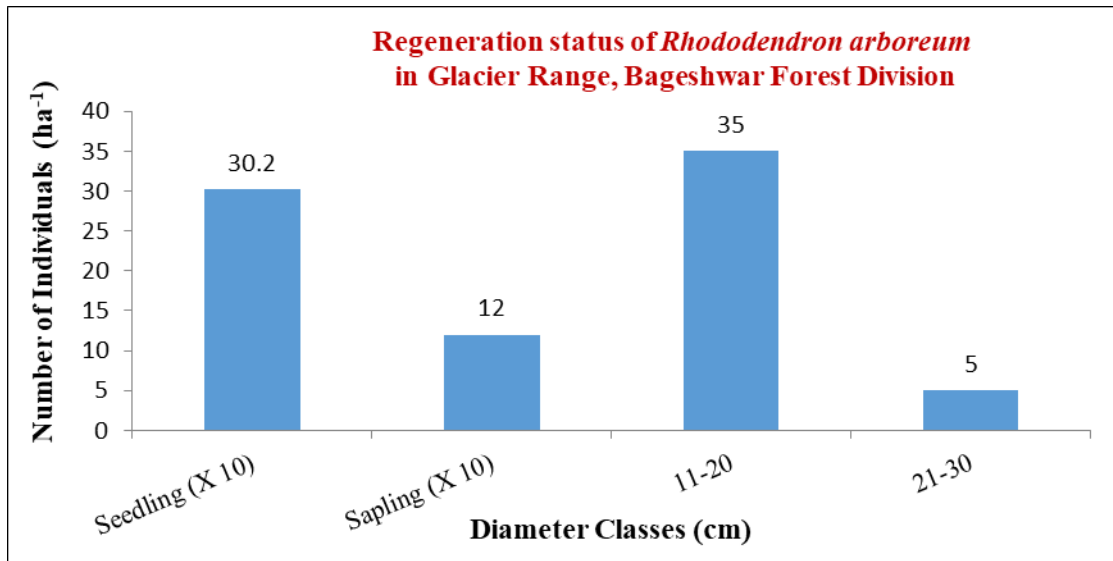
3.1.2.1 Study on Regeneration status

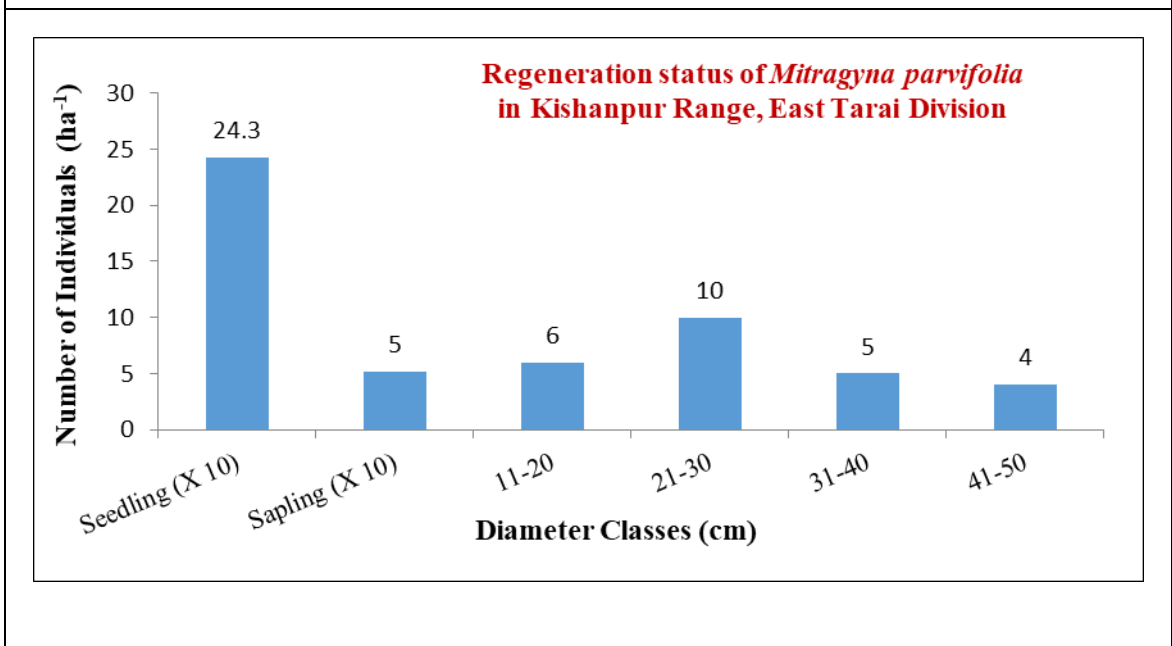
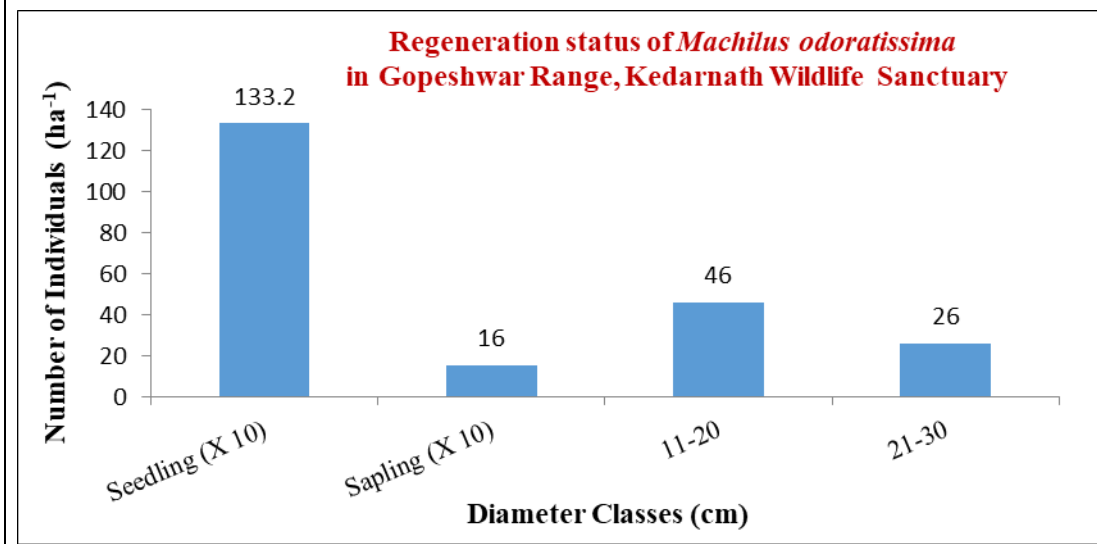
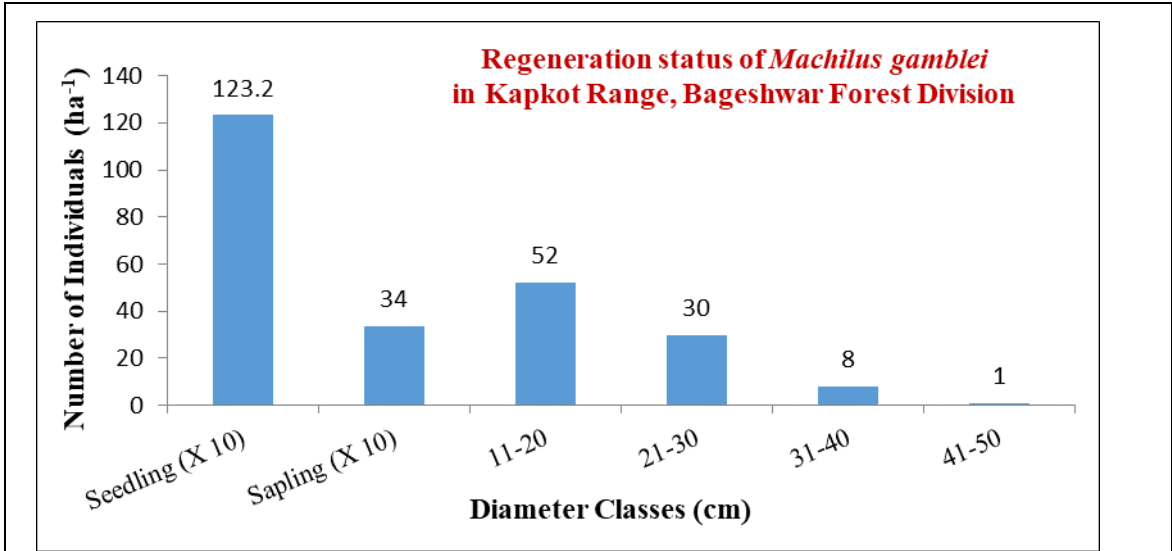
Regeneration status of selected species was estimated for different Forest Divisions of Uttarakhand viz *Spondias pinnata* (Narendra Nagar Forest Division), *Sterculia villosa* (Kishanpur Range, East Tarai Forest Division; Rajaji National Park; Kempty Range, Mussoorie Forest Division; Rudraprayag Range, Rudraprayag Forest Division; Bhilangana Range; Tehri Dam –I Forest Division), *Rhododendron arboreum* (Lohaghat Range, Champawat Forest Division; Taknor Range, Uttarkashi Forest Division; Glacier Range, Bageshwar Forest Division; South Jakholi Range, Rudraprayag Forest Division), *Salix tetrasperma* (Lohaghat Range, Champawat Forest Division; Surai Range, East Tarai Forest Division), *Schleichera oleosa* (Dolly Range, East Tarai Forest Division; Dehchauri Range, Ram Nagar Forest Division; Kaladungi Range, Ram Nagar Forest Division; Shyampur Range, Rajaji National Park; Khatima Range, East Tarai Forest Division), *Machilus gamblei* (Kapkot Range, Bageshwar Forest Division; Dogaon, Nainital Forest Division), *Machilus odoratissima* (Gopeshwar Range, Kedarnath Wildlife Sanctuary; Glacier Range, Bageshwar Forest Division; Manora Range, Nainital Forest Division),

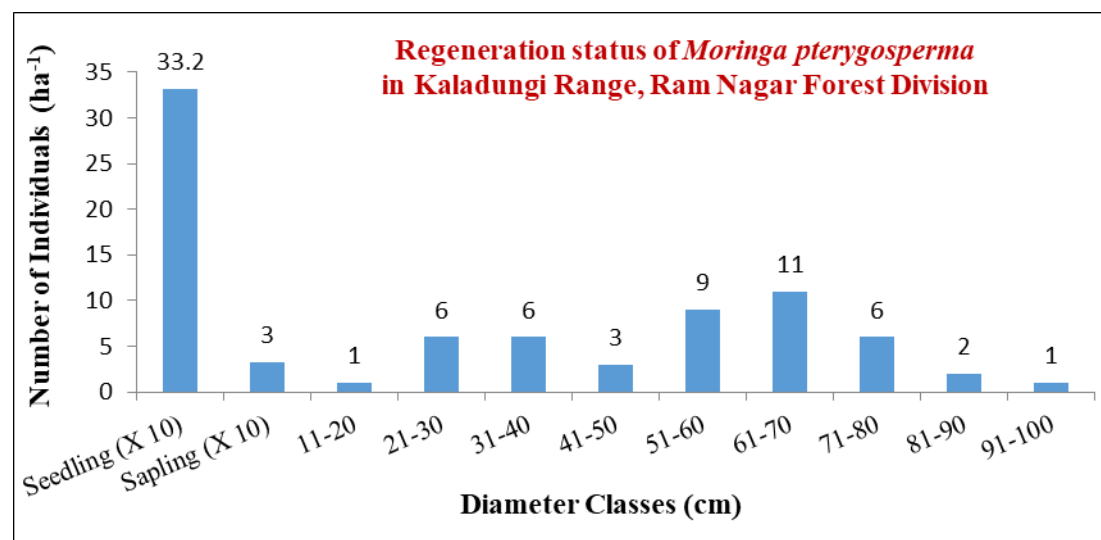
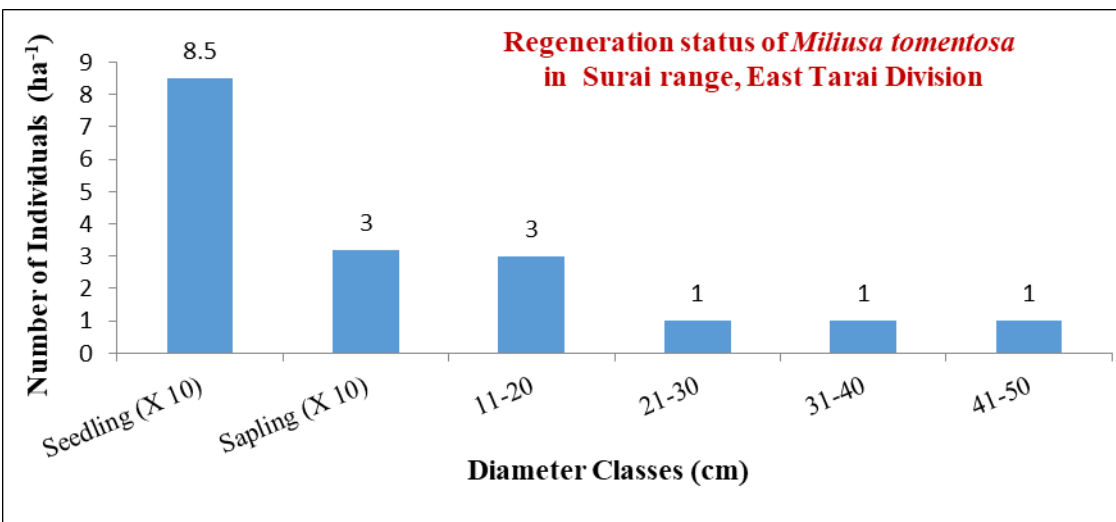
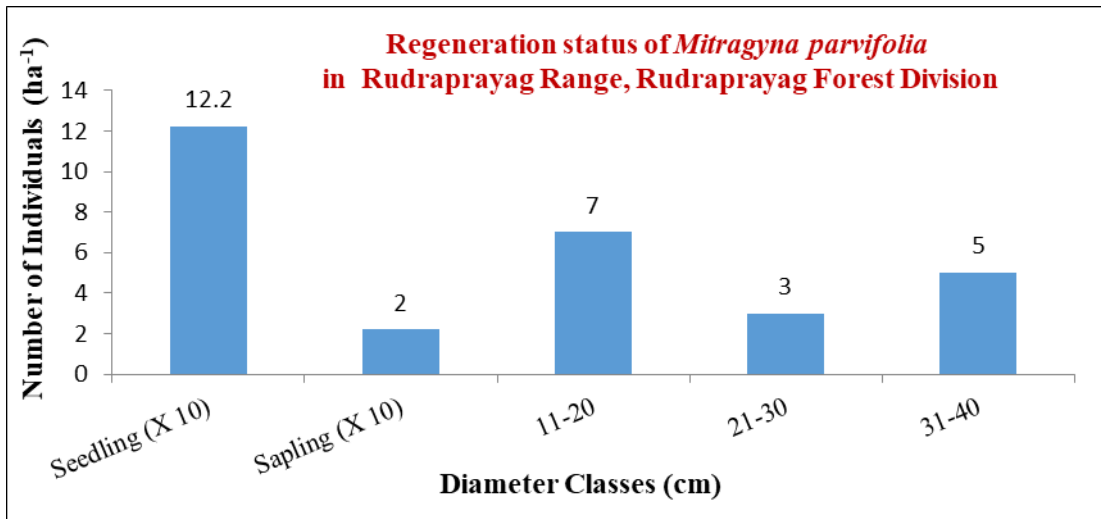
Mitragyna parvifolia (Kishanpur Range, East Tarai Division; Shyampur Range, Rajaji National Park); Rudraprayag Range, Rudraprayag Forest Division), *Miliusa tomentosa* (Surai Range, East Tarai Forest Division) *Moringa pterygosperma* (Kaladungi Range, Ram Nagar Forest Division; Saklana Range Tehri Forest Divison; Dehchauri Range, Ramnagar Forest Division), *Olea cuspidata* (Kempty Range, Mussoorie Forest Division; Deogarh Range, Chakrata Forest Division), *Olea paniculata* (Saklana Range, Tehri Forest Divison), *Oroxylum indicum* (Raipur Range, Mussoorie Forest Divison; Motichur Range, Rajaji National Park; Dharchula Range, Pithoragarh Forest Division), *Picea smithiana* (Gangotri Range, Uttarkashi Forest Division; Chopta, Kedarnath Wildlife Sanctuary; South Jakholi Range, Rudraprayag Forest Division), *Flacourtia jangomas* (Lohaghat Range, Champawat Forest Division; Khatima Range, East Tarai Forest Division; Mansa Devi Range, Rajaji National Park), *Garuga pinnata* (Nandhaur Wildlife Sanctuary, Shyampur Range, Rajaji National Park; Naogaon Range, Upper Yamuna Forest Division, *Holoptelia integrifolia* (Dolly Range, East Tarai Forest Division; Nandhaur Wildlife Sanctuary; Mansa Devi Range, Rajaji National Park), *Hovenia dulcis* (Sandra Range, Tons Forest Division; Rupin Range, Govind Pashu Vihar Division); *Kydia calycina* (Kishanpur Range, East Tarai Forest Division; Surai Range, East Tarai Forest Division), *Litsaea glutinosa* (Surai Range, East Tarai Forest Division; Kosi Range (Ram Nagar Forest Division), *Madhuca longifolia* (Surai Range, East Tarai Forest Division); Kosi Range, Ramnagar Forest Division), *Lagerstroemia parviflora* (Dehchauri Range, Ram Nagar Forest Division; Khatima Range, East Tarai Forest Division; Shyampur Range, Rajaji National Park; Kaladungi Range, Ram Nagar Forest Division).

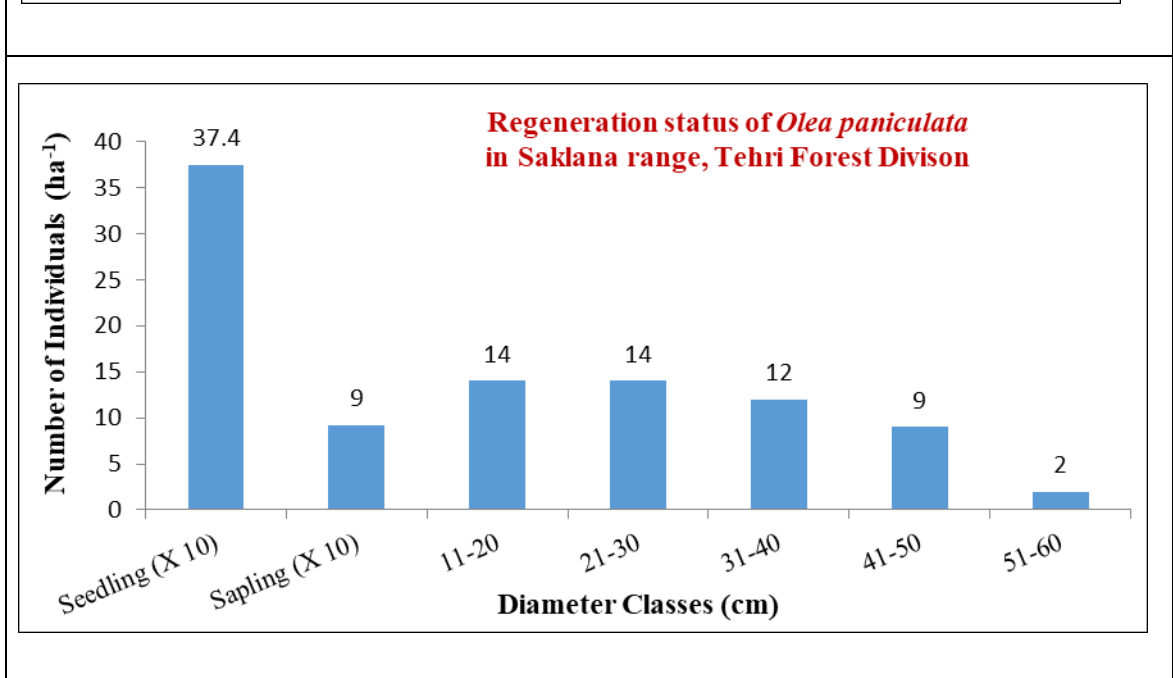
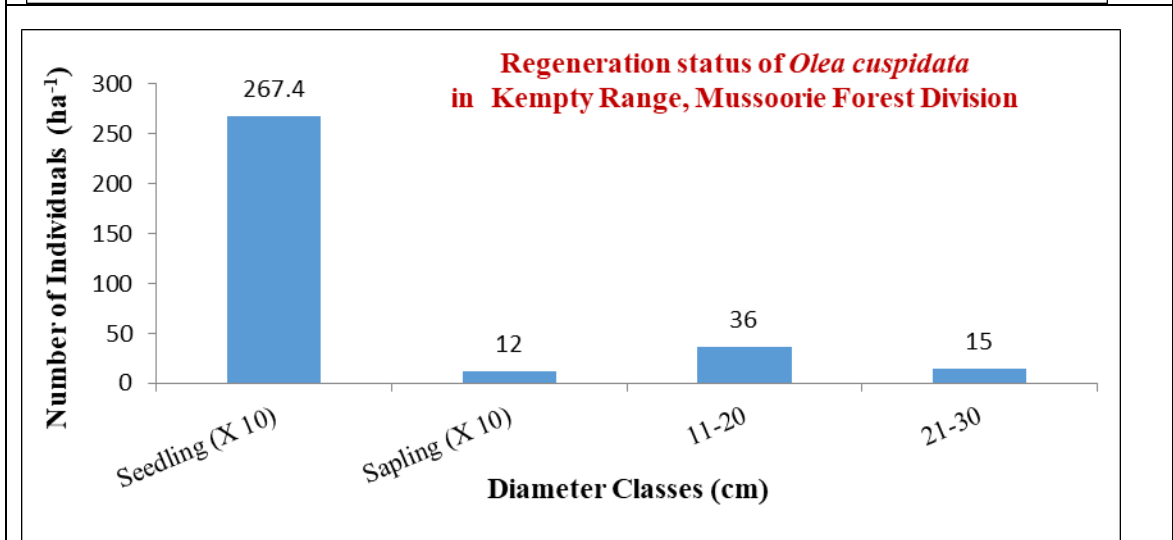
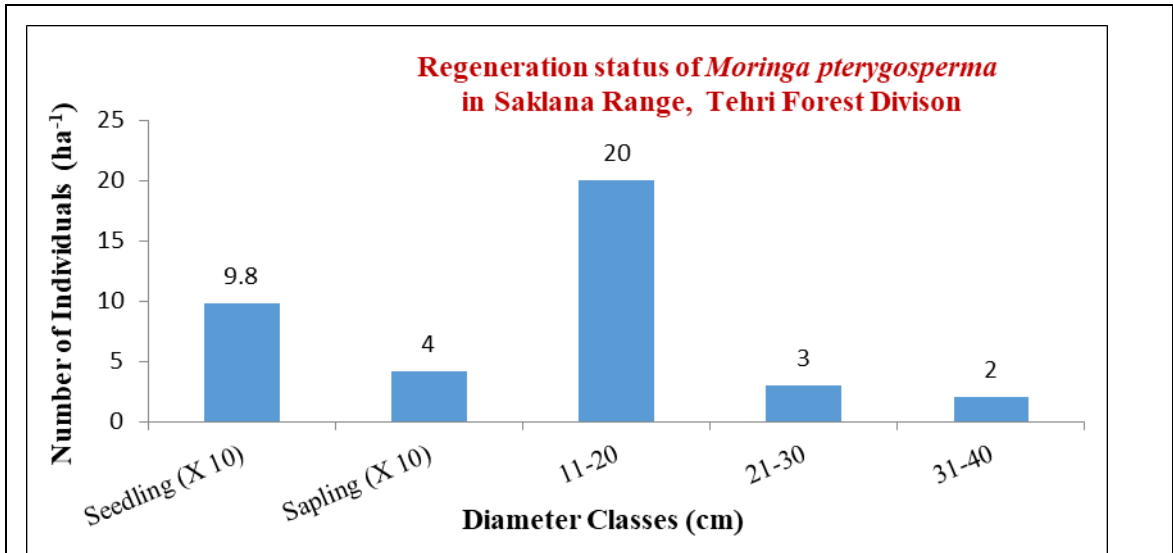


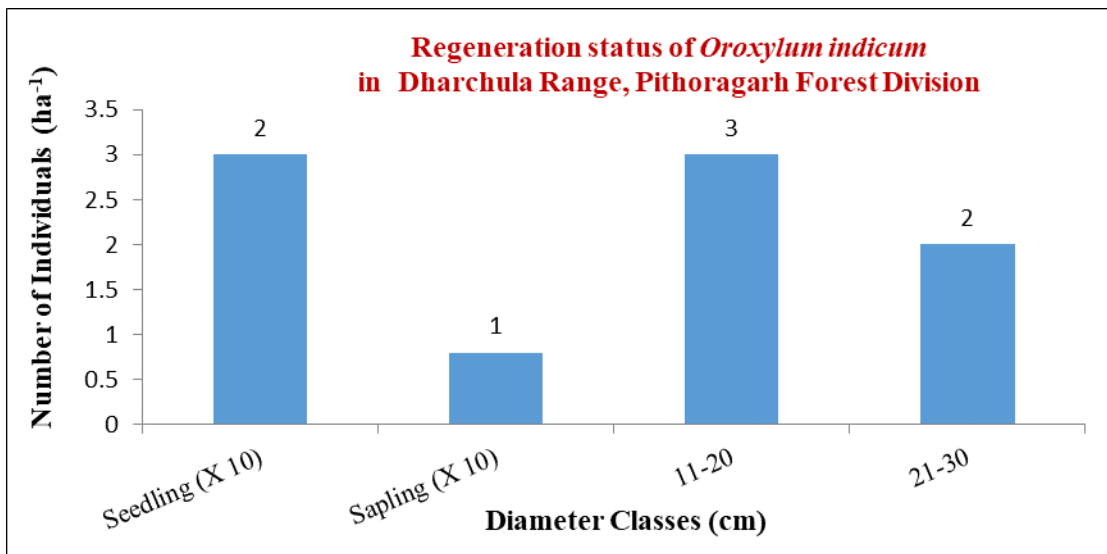
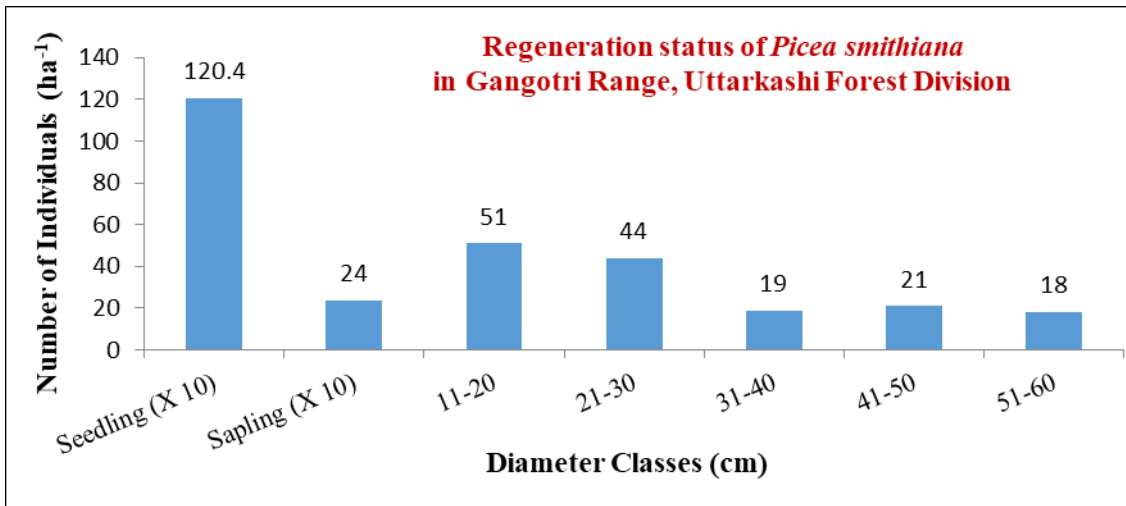
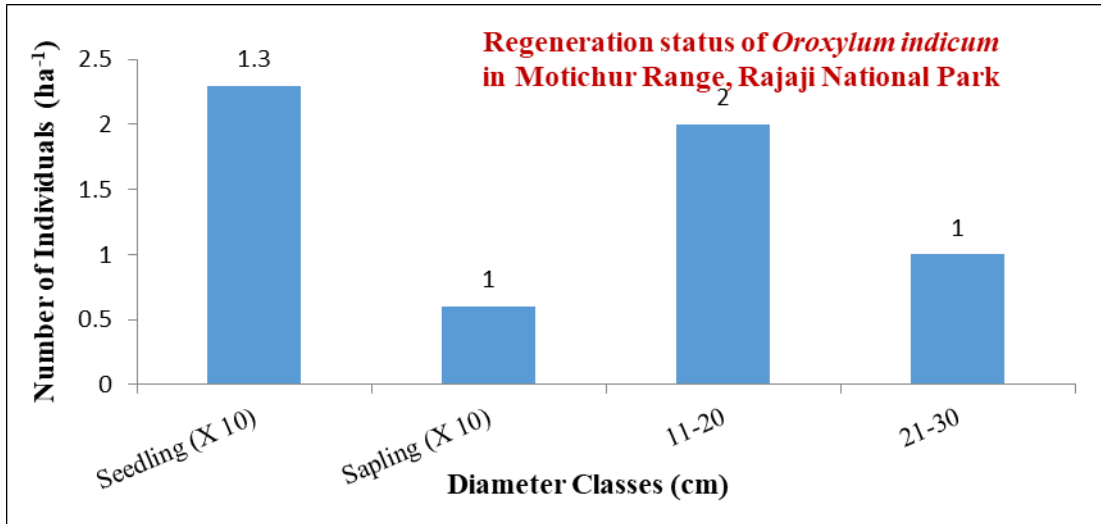


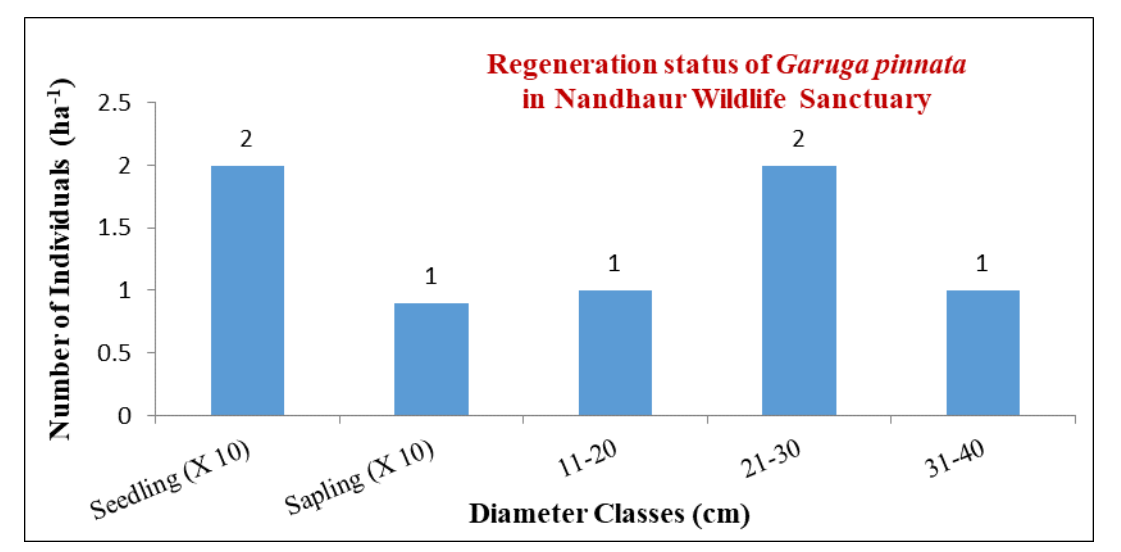
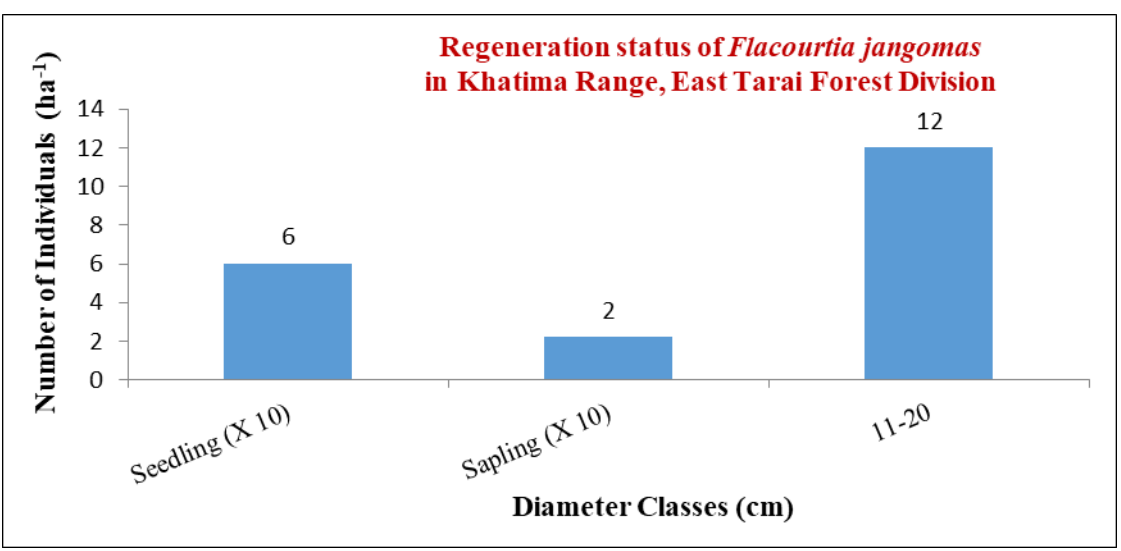
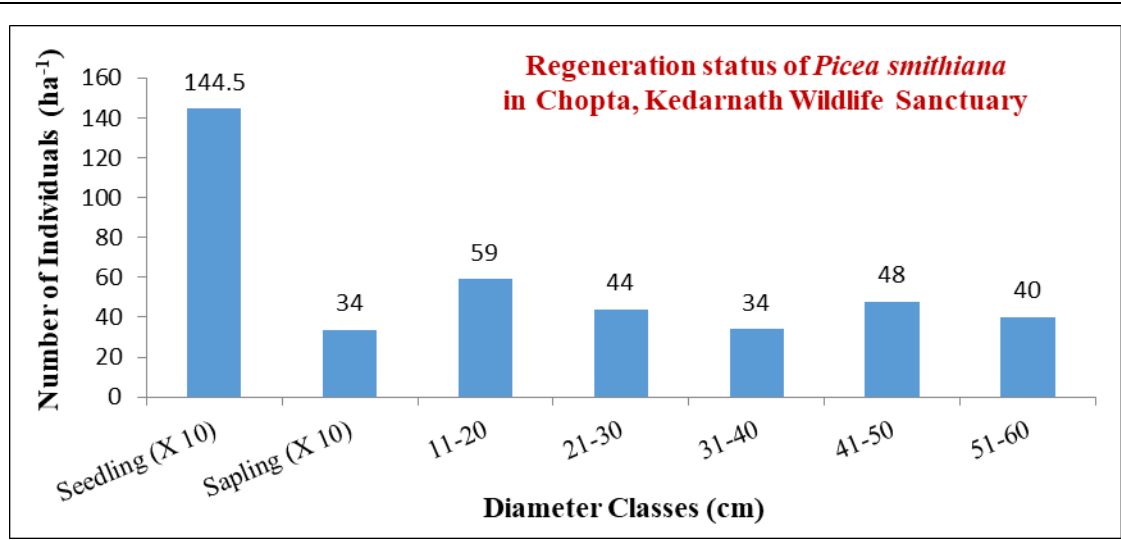


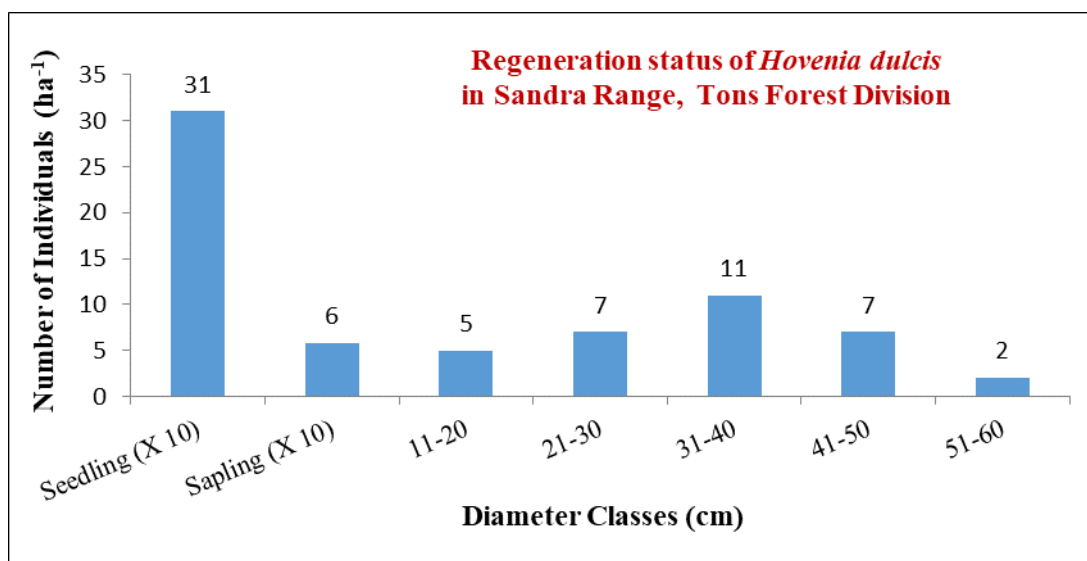
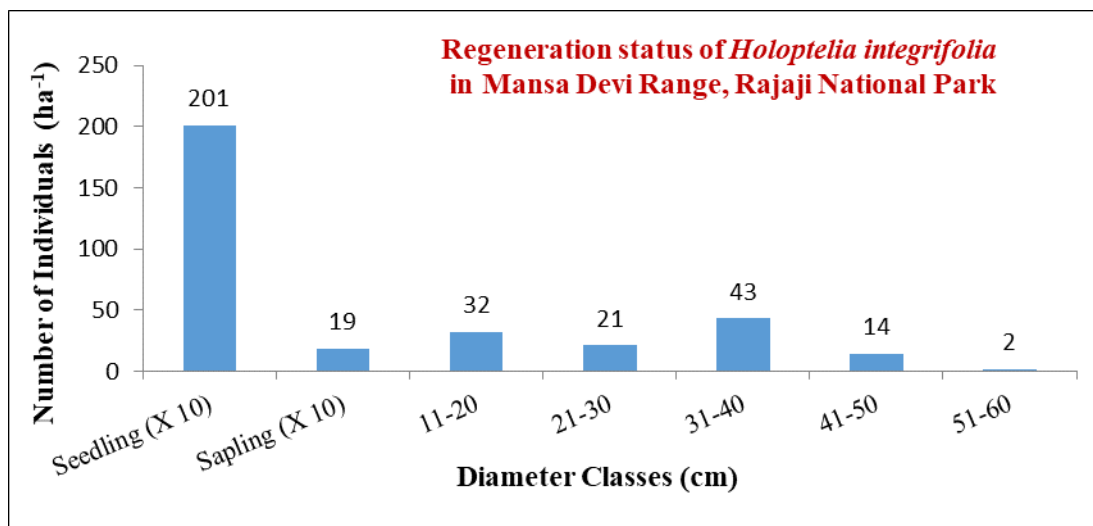
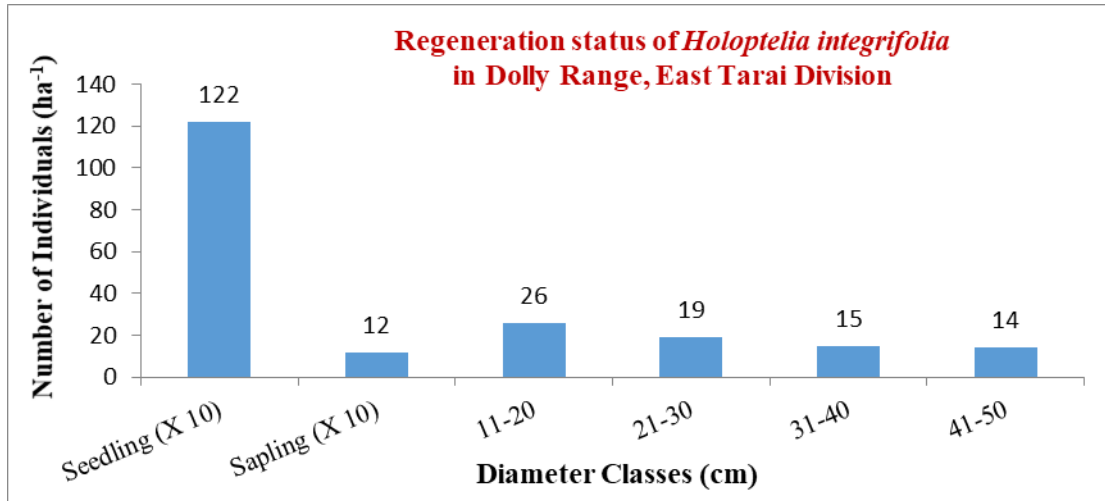


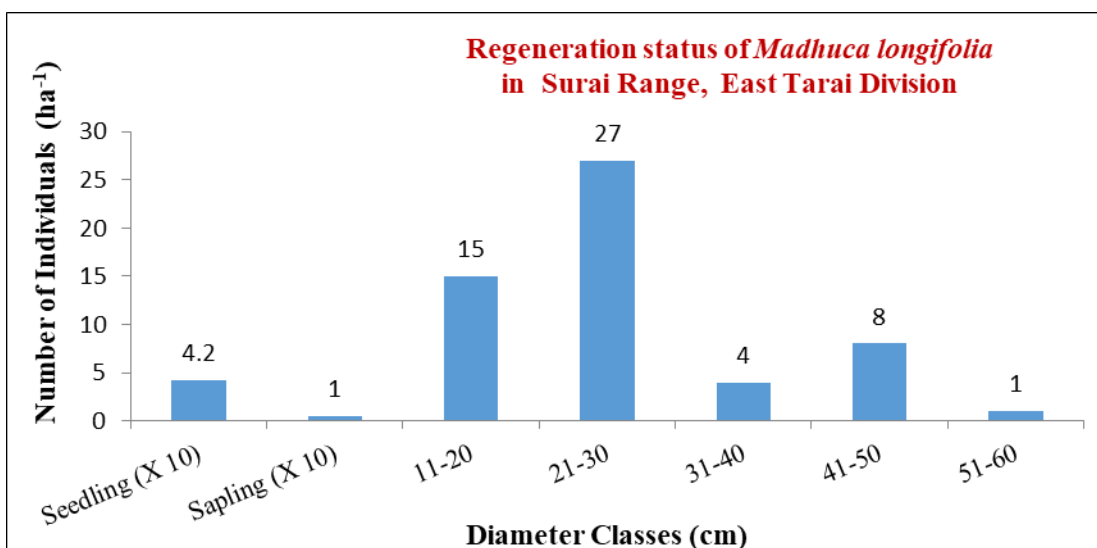
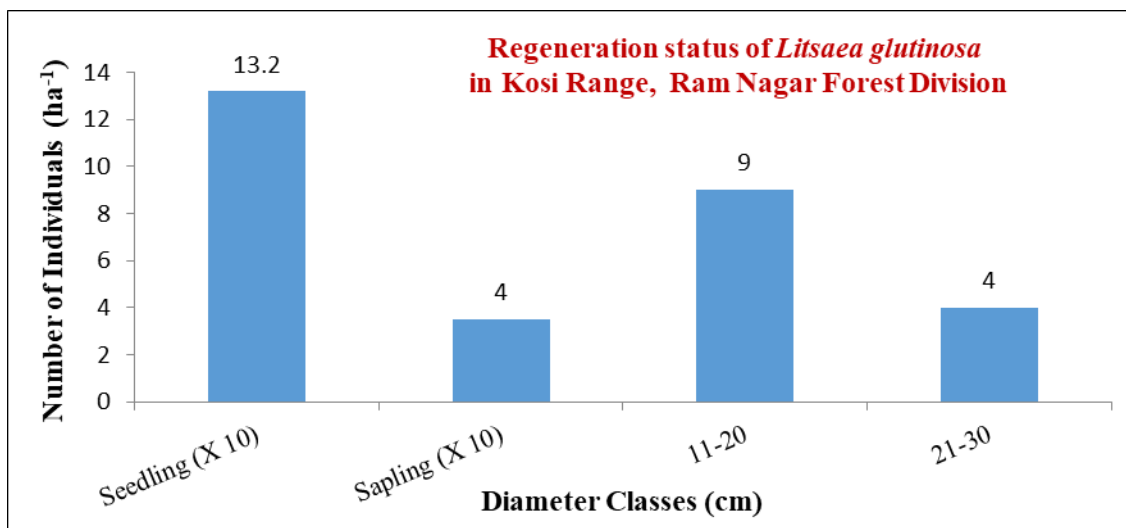
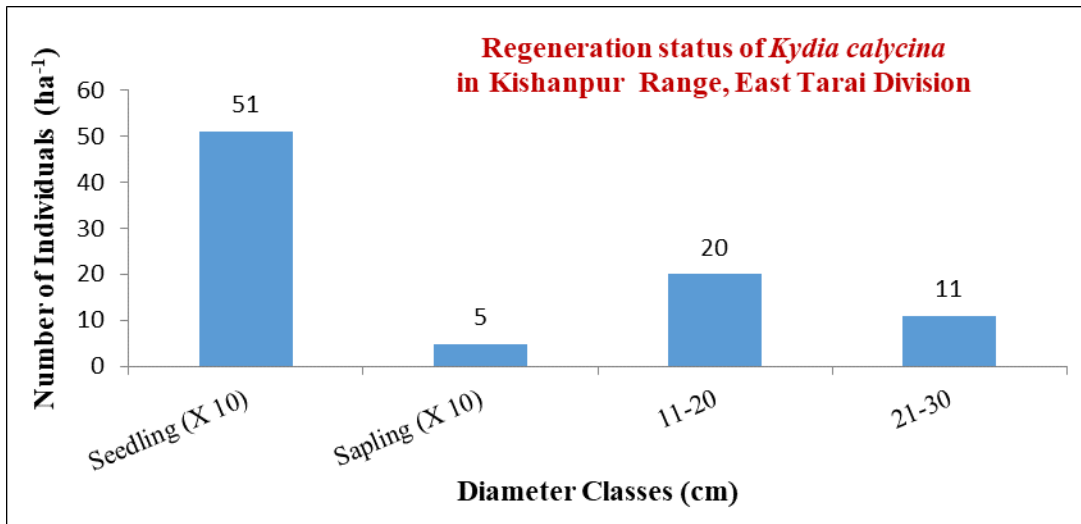












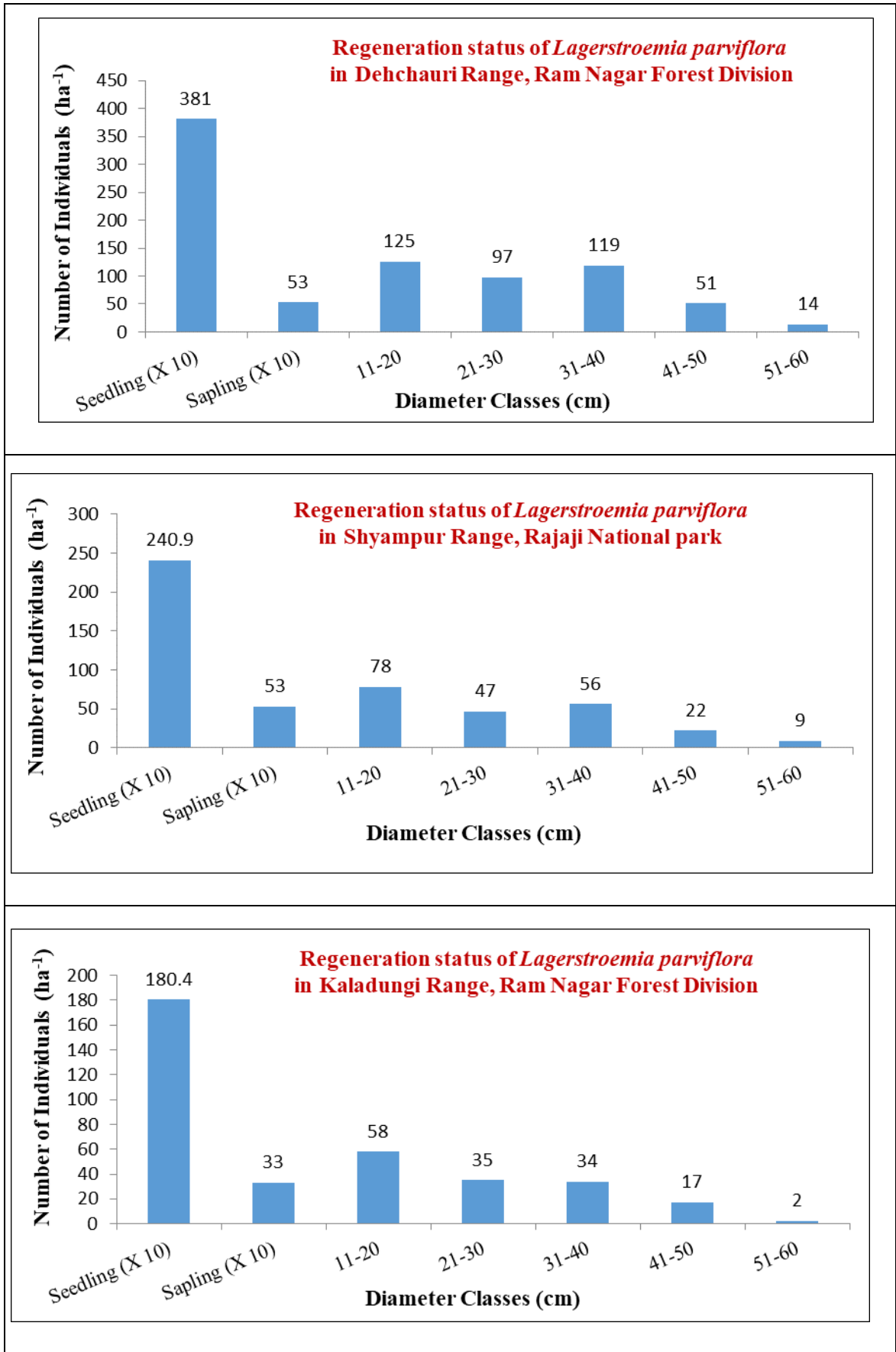


Figure 2: Regeneration status of different species

3.1.2.2 Description of Species

During the period, taxonomic description of the **50** Nos of FGR species has been prepared. It includes local name, synonyms, distribution (global, country and Uttarakhand), taxonomic description and live images of the species.

3.1.2.3 Preparation of Eco-Distribution maps

The map under the process was updated with the GPS points. The updated eco-distribution maps have been shown in Fig.3.

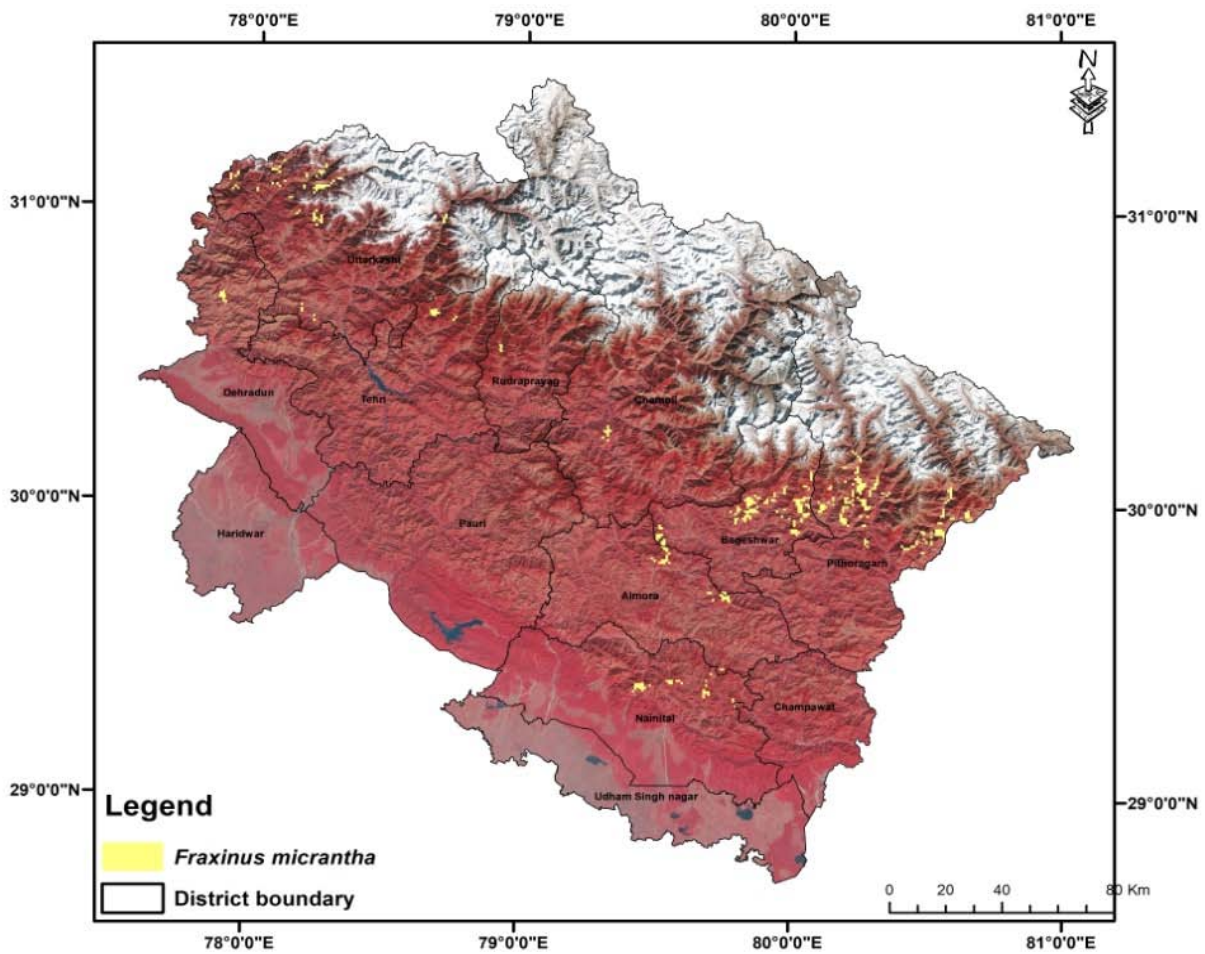


Figure 3: Eco-distribution map of *Fraxinus micrantha*

B. FGR SEED AND GERMPLASM STORAGE

i. Population survey and seed collection of FGR species

Field tours were undertaken in different forest areas for population survey to assess seed maturity and for seed collection of prioritized FGR species of the conservation concern. Fruits were collected upon maturity. Seeds of the following FGR species were collected from identified and marked populations. Following species were identified and their geo-coordinates were marked:

Table 1: Geographical locations of seed sources of FGR species:

S. No.	Species	Geographical location	GPS Co-ordinates	Altitude(m)
1.	<i>Albizia lucidior</i>	Garhi Cantt, Dehradun FD.	30°21'07.8" N 78°01'46.4" E	996
2.	<i>Alnus nepalensis</i>	Khirsu, Civil Soyam Garhwal Forest Division	30°10'45.6" N 78°51'87.0" E	1665
3.	<i>Cocculus laurifolius</i>	Mussoorie Forest Division	30°24'99.7" N 78°04'62.5" E	1050
4.	<i>Koelreuteria paniculata</i>	FRI Campus, Dehradun	30°23'56.5" N 78°58'46.2" E	652
5.	<i>Lyonia ovalifolia</i>	Sanjha Darbar, Mussoorie Forest Division	30°28'20.2" N 78°03'62.9" E	1913
6.	<i>Terminalia chebula</i>	FRI Campus, Dehradun	30°23'56.8" N 78°58'46.5" E	654
7.	<i>Terminalia citrina</i>	FRI Campus, Dehradun	30°23'56.7" N 78°58'46.3" E	656



Seed collection of *Lyonia ovalifolia*



***Albizia lucidior* tree with pods**

Figure 4: Collection of seeds and pods from different FGR species

ii. Seed Extraction

Seeds from fleshy or pulpy fruits were extracted by macerating/crushing and then washing thoroughly in water, while the seeds borne in pods or capsules were extracted by threshing. Other methods like drying of seeds under shade, threshing, de-winging and picking by hand,

etc. were used as per the morphology of fruit/seed. The seed extraction and processing methods adopted for different species are described as follows:

Table 2: Methodology followed for seeds extraction of collected FGR species

S.No.	Species	Methodology
1.	<i>Albizia lucidior</i>	Pods were sun dried for 2-3 days and seeds were extracted manually.
2.	<i>Alnus nepalensis</i>	Fruits were shade- dried for 4-5 days then seeds were extracted and separated from the impurities/foreign material with the help of dodder sieve.
3.	<i>Cocculus laurifolius</i>	Fruits were kept for after-ripening for 3 days. The pulp was removed by rubbing manually on wired mesh and washed under running tap water.
4.	<i>Koelreuteria paniculata</i>	Seeds were separated from bladder like pods manually.
5.	<i>Lyonia ovalifolia</i>	Fruits were separated from branches and kept under shade for drying for 3-4 days. Fruits were split manually. Then seeds were extracted and any impurities were removed with the help of dodder sieve.
6.	<i>Terminalia chebula</i>	Fruits were soaked in water for 2-3 days, macerated and extracted seeds. Extracted seeds were shade dried for 6 to 7 days.
7.	<i>Terminalia citrina</i>	Fruits were soaked in water for 2 days. The pulp was removed by rubbing manually and extracted seeds were shade dried for 4 to 5 days.



Seeds of *Alnus nepalensis*



Pods of *Albizia lucidior*



Fruits of *Lyonia ovalifolia*



Fruits of *Cocculus laurifolius*

Figure 5: Extraction of seeds from fruits of different FGR species

iii. Seed moisture content and Germination percentage

Moisture contents of the extracted seeds were determined by Oven-Dry method. In this method, working sample of seed were weighed, then ground and placed in oven maintained at 103°C for 17±1hr (ISTA, 2010).

$$\text{Moisture Content \%} = (\text{Fresh weight} - \text{Oven dry weight}) / \text{Fresh weight} \times 100$$

Table 3: Seed moisture content and germination percentage of fresh seeds of different species

S.No.	Species	Location	M C (%)	Germination%
1.	<i>Albizia lucidior</i>	Garhi Cantt, Dehradun Forest Division.	12.97	90
2.	<i>Alnus nepalensis</i>	Khirsu, Civil Soyam Garhwal Forest Division	4.54	45 germinants/ 0.02gm seeds
3.	<i>Cocculus laurifolius</i>	Mussoorie Forest Division	16.3	90
4.	<i>Koelreuteria paniculata</i>	FRI Campus, Dehradun	7.98	87
5.	<i>Lyonia ovalifolia</i>	Sanjha Darbar, Mussoorie Forest Division	6.81	68 germinants/ 0.01gm seeds
6.	<i>Terminalia chebula</i>	FRI Campus, Dehradun	12.86	47
7.	<i>Terminalia citrina</i>	FRI Campus, Dehradun	10.67	74



Cocculus laurifolius



Lyonia ovalifolia



Alnus nepalensis



Albizia lucidior

Figure 6: Seed germination of FGR species

iv. **Quarterly viability test of stored seeds**

Viability test of the seeds kept under storage at 5°C was conducted through germination test, during the quarter.

Table 4: Quarterly germination percentage of the prioritized FGR species

S. No.	Species name	Germination%
1	<i>Aegle marmelos</i> (Chakata range)	93
2	<i>Aegle marmelos</i> (Rajaji)	55
3	<i>Alnus nepalensis</i> (Guptkashi)	7
4	<i>Aristolochia elegans</i>	7
5	<i>Betula utilis</i> (Mana)	27 germinants/0.02gm seeds
6	<i>Celastrus paniculatus</i> (Narkota)	91
7	<i>Celtis australis</i> (Chaprali)	14
8	<i>Crotolaria cytisoides</i> (Mussoorie)	47
9	<i>Dalbergia sissoo</i> (Dakpathar)	96
10	<i>Dalbergia sissoo</i> (Dakpathar)	96
11	<i>Fraxinus xanthoxyloides</i> (Niti)	22 (Pre-treatment: 0.03% GA ₃ for 24 hours)
12	<i>Myrica esculenta</i> (Chaukhutiya, Almora)	47 (Pre-treatment: Hot water soaking at 70 ⁰ C for 24 hours)
13	<i>Oroxylum indicum</i> (Rudraprayag)	95
14	<i>Pinus wallichiana</i> (Dhanaulti)	67
15	<i>Rhododendron arboreum</i>	9360 germinants/1 gm of seeds
16	<i>Rhus punjabensis</i> (Kantha)	6
17	<i>Toona ciliata</i> (Haldwani)	63
18	<i>Toona serrata</i> (Kempty Fall)	77
19	<i>Uncaria scandens</i>	7920 germinants/1 gm of seeds



Oroxylum indicum



Myrica esculenta



Celtis australis






Uncaria scandens


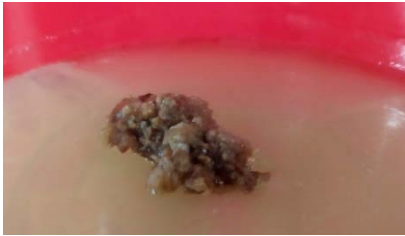

Figure 7: Quarterly germination test of the prioritized FGR species

v. ***In vitro* storage of FGR species**

Experiments carried out to devise *in vitro* regeneration or micro propagation protocols for selected species:

Table 5: *In vitro* regeneration or micropropagation protocols for selected species

1	<i>Desmodium oojeinense</i>
i)	Subculture of Calli: Callus cultures are being maintained on MS+ 1(mg/l) BAP+ AgNO ₃ for multiplication and storage
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Callus maintenance in 1(mg/l) BAP+</i></p>
2.	<i>Hippophae salicifolia</i>
i)	<i>In vitro</i> rooting
	<i>In vitro</i> rooting had been initiated in liquid and solid medium and is underway.
3.	<i>Albizia julibrisin</i>
i)	<i>In vitro</i> medium term storage using synthetic seeds
	<i>In vitro</i> raised shoot buds were used to create synthetic seeds using 3% sodium alginate and 100mM anhydrous CaCl ₂ and after a storage of eight weeks were allowed to regrow in the optimized medium (MS+1 mg/l BAP+ 0.5 mg/l KIN).
	<p><i>In vitro</i> response:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>a</p> </div> <div style="text-align: center;">  <p>b</p> </div> </div> <p>a) Preparation of synthetic seeds for medium term storage. b) Regrowth of shoot buds in encapsulated beads after eight weeks</p>
4.	<i>Aristolochia punjabensis</i>
i)	<i>In vitro</i> medium term storage using synthetic seeds
	Preparation of synthetic seeds of <i>A. punjabensis</i> for medium term storage is underway.
5.	<i>Dysoxylum gotadhora</i>
i)	<i>In vitro</i> shoot multiplication and medium term storage using synthetic seeds
	Shoot multiplication of the germinated seedlings and use of apical shoots for synthetic seed preparation and storage is underway.
6.	<i>Catamixis baccharoides:</i>
i)	<i>In vitro</i> seed germination
	Fresh seed inoculations were again made to have enough explants for medium term storage trials.
7.	<i>Oroxylum indicum:</i>
i)	<i>In vitro</i> medium term storage using synthetic seeds

	<p><i>In vitro</i> raised shoot buds were used to create synthetic seeds using 3% sodium alginate and 100mM anhydrous CaCl₂ and after a storage of eight weeks were allowed to regrow in the optimized medium (MS+ 0.5 mg/l KIN+ 25mg/l glutamine).</p> <p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Preparation of synthetic seed & germination</i></p>
ii)	<p>Hardening of the rooted plantlets</p> <p>Rooted plantlets were acclimatized and hardened in hardening chambers in sterilized coco-pit mixture.</p>
8.	<p><i>Butea peltita</i></p>
i)	<p><i>In vitro</i> callus maintenance</p> <p>The callus is being maintained and stored in MS+1 (mg/l) BAP + AgNO₃</p>
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Callus maintenance in 1(mg/l) BAP+ AgNO3</i></p>
9.	<p><i>Hymenodictyon orixense</i></p>
i)	<p>Hardening of the rooted plantlets</p> <p>Rooted plantlets were acclimatized and hardened in hardening chambers in sterilized coco-pit mixture.</p>
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>In vitro rooting in H. orixense</i></p>
10	<p><i>Diploknemma butyraceae</i></p>
i)	<p><i>In vitro</i> bud initiation</p> <p><i>In vitro</i> apical bud initiation and proliferation is going on.</p>

vi. Pollen storage experiments

The experiments have been completed and documentation of protocols is underway.

C. FGR CHARACTERIZATION

i. Molecular Characterization

3.3.1.1 Genotyping using SSR markers:

The details of SSR markers validated in different species and number of populations genotyped using validated SSRs during the quarter are shown in the table:

Table 6: Genotyping using SSR markers in different species in current quarter

Species	SSRs validated	Total Populations	Genotyping status	
			Populations	Primers
<i>R. arboreum</i>	10	27	27	10
<i>T. wallichiana</i>	10	21	21	10
<i>B. utilis</i>	17	9	9	17

Genotyping work has been completed in *R. arboreum* along with data compilation. Genotyping of missing data of *R. arboreum* is still in progress. *B. utilis* leaf samples for two populations to be collected from the Uttarkashi.

ii. Chemical Characterization

Table 7: Biochemical characterization in selected species in current quarter

Species	Biochemical characterization	Population	10-DAB-III content ($\mu\text{g} / \text{g}$)
<i>Taxus wallichiana</i>	Needles were lyophilized, milled and extracted with methanol. The extracts were purified using column chromatography for their 10-Deacetylbaaccatin-III assisted chemical screening. HPLC assisted chemical screening of the purified extracts led to identify and quantify 10-DAB-III in all populations.	TB-10	-
		TB-13	-
		TB-14	-
		TB-21	-

D. FGR CONSERVATION

The field gene banks of *Diploknema butyracea*, *Rhododendron arboreum*, *Myrica esculenta*, *Cinnamomum tamala*, and *Toona ciliata* established in the previous quarters were maintained. Germplasm conserved in the field gene banks are growing very well.



Figure 8: Field gene banks established for different species

4. Cumulative Progress Report

Background Information

Forest Genetic Resources (FGRs) constitute a very important sub-set of biodiversity. Conserving FGR is vital, as they are unique and irreplaceable resources for the future. In India alone, more than 340 million people are estimated to be dependent upon the FGRs for their livelihoods. There is a definite need to address the FGR related issues through a comprehensive FGR conservation and development strategy and implementation plan.

As per present state of knowledge, 18,236 higher plant species (18,159 Angiosperms and 77 Gymnosperms) is documented from India so far (*BSI, 2015: Plant Discoveries 2014*). More than 80% of this higher plant diversity is contained in the forest habitats (4,500 species). About half of this forest plant diversity constitutes FGRs (7,250 species), the remaining being herbaceous flora including soft climbers, twiners, herbs, and grasses. FGRs contain a huge potential in ensuring food and health security of the country's burgeoning human population and its livestock.

To generate understanding and knowledge on FGR, and to develop and strengthen in situ and ex situ FGR conservation programmes, the National CAMPA Advisory Council (NCAC) of Ministry of Environment and Forests & Climate Change, Govt. of India has sanctioned a project entitled "National Program for Conservation and Development of Forest Genetic Resources: Pilot Project Proposal to be implemented at FRI on Creation of Centre of Excellence on Forest Genetic Resources (CoFGR)". The 4th installment of the project 127.05 lakh was received on 4th September 2018. A brief progress of activities for the period till December 2019 has been summarized below:

Progress of Works

As per the action plan of the project, activities were initiated and following four working groups have been created in FRI to achieve the targets of the project:

- i. FGR Documentation
- ii. FGR Seed and Germplasm Storage
- iii. FGR Characterization Cell
- iv. FGR Conservation Cell

The brief description of the activities so far taken up has been detailed below:

A. FGR documentation

1. Upgradation of DD Herbarium

a) Purchase of mobile compactors and renovation of herbarium building:

Mobile herbarium compactors have been procured and installed. With the completion of renovation work of new herbarium hall, 100% of the Dicotyledonous floral specimens have been successfully transferred.

b) Digitization of DD Herbarium

Herbarium is a repository and source of knowledge about the flora of a region or a locality or a country. It provides preserved materials for taxonomic, cytological and anatomical studies. It is a data store in which the information on plants is available. It also acts as a reservoir of gene pool studies.

The herbarium of Forest Research Institute, commonly known as Dehradun or DD herbarium is one of the oldest and most renowned collection in the country. The origin of the Herbarium of the Forest Research Institute (Dehra Dun Herbarium) dates back to the early 20th century in 1908 with the amalgamation of forest school herbarium which was founded in 1890 and Saharanpur herbarium (Botanical Garden of Saharanpur), which started in 1816. Today's Dehra Dun Herbarium (DD) collection is inheritance of over 200 years of perilous botanical endeavour. The herbarium's total holding is over 3,50,000 (350 Thousand) specimens and approximately 1,300 type specimens. The oldest collection of DD Herbarium is from Lower Assam valley, collected in 1708. DD Herbarium collection is an irreplaceable source of data not only for the Indian subcontinent collection but also for the worldwide flora.

Being the second largest herbarium of the country, the collection offers a unique insight into the flora of the Indian subcontinent. To make the herbarium data available to taxonomists worldwide, an urgent need for digitizing and developing a database was felt. The Herbarium digitization was initiated in 2008-2009 supported through in-house funding with an original objective to digitize one specimen per species of flowering plants. Sooner it was realized that one specimen may not be sufficient to cover the morphological variations existing within species therefore, two more specimens of each species were digitized. This objective was achieved with the financial support from Ministry of Environment, Forest and Climate Change (MoEF&CC) under the CAMPA scheme 'Pilot project on : Creation of Centre of Excellence on Forest Genetic Resources (FGRs). A database was developed which enabled it for its online access to the researchers and students worldwide. The Herbarium specimens are digitized at 600 dpi and JPEG images of ≤ 10 MB are made available for online usage with same level of clarity as with TIFF images. The database now has record of 1,02,000 specimens belonging to 39,916 species of flowering plants representing approximately 1/3rd of total Herbarium collection. These 39,916 species belong to 5514 genera and 202 families and the assignment of families is as per Bentham and Hooker System of Classification.

Every year the DD herbarium receives about 2000 to 2500 online query a month on species identification and approx. 4000 visitors' visits every years this precious repository for consultation/visit. Having this valuable information in online platform, it will give a ready access to national as well as international audience; educational institutions, botanists, researchers and students with less expenses and without causing potential damage to the unique materials.

Digital databasing of **68,000** specimens was targeted. Out of which **63,766** specimens have been entered in DD herbarium database.

Table 8: Growth of the DD dataset in the period (April 2017 to September, 2020)

Period	Image Scanning	Image Processing	Data Basing
February 2016-March, 2017*	21931	21931	21931
April-June, 2017	5250	5000	457
July-September, 2017	4416	4308	4106
September-December, 2017	7526	6259	1539
January – March, 2018	8592	8592	0
April-June, 2018	7605	7507	0
July-September,2018	5560	6827	0
October-December, 2018	3198	4211	2400
January-March, 2019	8450	5490	1948
April-June,2019	2939	2939	2939
July – September, 2019	2197	2712	4250
October- December 2019	0	1000	5200
January- March, 2020	0	0	4870
April-June, 2020	0	0	3000
July-Sept., 2020	0	0	4250
Oct-Dec., 2020	0	0	6876
January – March, 2021	0	0	4250
Total	77664	76776	68016

(* 1st year of project period funds received from ICFRE and March, 2017 onwards funded under CoFGR project.)

2. Documentation of FGR species

a) Listing and Prioritization of the FGR Species

A list of 250 priority species (141- tree species, 29 shrubs, 15 lianas/woody climbers and 65 RET species) was prepared, out of which 50 species were selected for preparation of eco-distribution maps. Distribution of 250 species has been traced from DD Herbarium, BSI Herbarium, and Garhwal University Herbarium and working plans of different Forest Divisions of Uttarakhand.

b) FGR distribution records

DD Herbarium, BSI Herbarium (Northern Circle) and Garhwal University Herbarium was consulted. Detailed information about projects species was collected. Distribution record from literature has been consulted for selected FGR species.

c) Field Survey for distribution

Field surveys have been conducted in different districts of Uttarakhand. Total **250** species have been traced out from different locations of Uttarakhand.

Table 9: List of the species recorded in different forest ranges

<p>Kalsi Soil Conservation Division (Timali Range): Trees: <i>Acacia catechu</i>, <i>Adina cordifolia</i>, <i>Aegle marmelos</i>, <i>Albizia lebbek</i>, <i>Anogeissus latifolia</i>, <i>Bauhinia malabarica</i>, <i>Bauhinia semla</i>, <i>Bauhinia variegata</i>, <i>Bischofia javanica</i>, <i>Bombax ceiba</i>, <i>Bridelia retusa</i>, <i>Buchanania lanzan</i>, <i>Butea monosperma</i>, <i>Careya arborea</i>, <i>Cassia fistula</i>, <i>Catunaregam spinosa</i>, <i>Cordia dichotoma</i>, <i>Desmodium oojinense</i>, <i>Diospyros melanoxyton</i>, <i>Diospyros Montana</i>, <i>Ficus auriculata</i>, <i>Ficus benghalensis</i>, <i>Ficus racemosa</i>, <i>Ficus rumphii</i>, <i>Ficus semicordata</i>, <i>Flacourtia indica</i>,</p>

<p><i>Holoptelea integrifolia</i>, <i>Kydia calycina</i>, <i>Lannea coromandelica</i>, <i>Lagerstroemia parviflora</i>, <i>Litsea chinensis</i>, <i>Machilus gamblei</i>, <i>Mangifera indica</i>, <i>Melia azedarach</i>, <i>Milium velutina</i>, <i>Mitragyna parviflora</i>, <i>Morus australis</i>, <i>Oroxylum indicum</i>, <i>Phoenix humilis</i>, <i>Phyllanthus emblica</i>, <i>Pinus roxburghii</i>, <i>Pongamia pinnata</i>, <i>Pterosperma acerifolium</i>, <i>Semecarpus anacardium</i>, <i>Shorea robusta</i>, <i>Sterculia villosa</i>, <i>Syzygium cumini</i>, <i>Terminalia alata</i>, <i>Terminalia arjuna</i>, <i>Terminalia bellirica</i>, <i>Terminalia chebula</i> and <i>Toona ciliata</i></p> <p>Shrubs: <i>Adhatoda vasica</i>, <i>Woodfordia fruticosa</i>, <i>Ziziphus mauritiana</i>, <i>Calotropis procera</i>, <i>Colebrookea oppositifolia</i> and <i>Rhus parviflora</i></p> <p>Climbers: <i>Bauhinia vahii</i>, <i>Tinospora cordifolia</i> and <i>Cryptolepis buchananii</i></p>
<p>Haldwani Forest Division (Sharda Forest Range):</p> <p>Trees: <i>Shorea robusta</i>, <i>Adina cordifolia</i>, <i>Mitragyna parviflora</i>, <i>Cordia dichotoma</i>, <i>Ficus benghalensis</i>, <i>Ficus rumphi</i>, <i>Ficus racemosa</i>, <i>Toona ciliata</i>, <i>Aegle marmelos</i>, <i>Cassia fistula</i>, <i>Syzygium cumini</i>, <i>Moringa oleifera</i>, <i>Dalbergia sissoo</i>, <i>Acacia catechu</i>, <i>Wendlandia heynei</i> and <i>Strebulus asper</i></p> <p>Shrubs: <i>Ziziphus mauritiana</i>, <i>Adhatoda vasica</i> and <i>Debregeasia longifolia</i></p> <p>Climbers: <i>Bauhinia vahlii</i></p>
<p>Nainital Forest Division (Bhowali Forest Range):</p> <p>Trees: <i>Quercus leucotrichophora</i>, <i>Pinus roxburghii</i>, <i>Myrica esculenta</i>, <i>Cornus capitata</i>, <i>Ficus neriifolia</i>, <i>Ficus auriculata</i>, <i>Prunus cerasoides</i>, <i>Alnus nepalensis</i>, <i>Bauhinia semla</i>, <i>Rhododendron arboreum</i>, <i>Cassia fistula</i>, <i>Toona ciliata</i> and <i>Sapium insigne</i></p> <p>Shrubs: <i>Debregeasia longifolia</i>, <i>Debregeasia saeneb</i>, <i>Princepia utilis</i> and <i>Rubus ellipticus</i></p> <p>Climbers: <i>Bauhinia vahli</i> and <i>Cryptolepis buchanani</i></p>
<p>East Tarai Forest Division (Khatima, Surai, Kilpura Forest Ranges):</p> <p>Trees: <i>Acacia catechu</i>, <i>Aegle marmelos</i>, <i>Albizia lebbbeck</i>, <i>Albizia procera</i>, <i>Bauhinia malabarica</i>, <i>Buchanania lanzan</i>, <i>Bridelia retusa</i>, <i>Carallia brachiata</i>, <i>Cassia fistula</i>, <i>Cordia dichotoma</i>, <i>Dillenia pentagyna</i>, <i>Dalbergia sissoo</i>, <i>Phyllanthus embelica</i>, <i>Ficus bengalensis</i>, <i>Ficus rumphii</i>, <i>Ficus semicordata</i>, <i>Ficus racemosa</i>, <i>Gmelina arborea</i>, <i>Grewia asiatica</i>, <i>Holoptelia integrifolia</i>, <i>Kydia calycina</i>, <i>Hymenodictyon excelsum</i>, <i>Lagerstroemia parviflora</i>, <i>Litsea chinensis</i>, <i>Litsea monoptela</i>, <i>Madhuca longifolia</i>, <i>Mitragyna parvifolia</i>, <i>Oroxylum indicum</i>, <i>Putranjiva roxburghii</i>, <i>Schleichera oleosa</i>, <i>Semecarpus anacardium</i>, <i>Shorea robusta</i>, <i>Sterculia villosa</i>, <i>Stereospermum chelonoides</i>, <i>Syzygium cumini</i>, <i>Terminalia bellirica</i>, <i>Terminalia chebula</i>, <i>Terminalia tomentosa</i> and <i>Toona ciliata</i>.</p> <p>Shrubs: <i>Adhatoda vasica</i>, <i>Asparagus adscendens</i>, <i>Callicarpa macrophylla</i>, <i>Helicteres isora</i>, <i>Catunaregam spinosa</i> and <i>Ziziphus mauritiana</i>.</p> <p>Climbers: <i>Bauhinia vahlii</i>, <i>Calamus tenuis</i>, <i>Cryptolepis buchananii</i>, <i>Pueraria tuberosa</i> and <i>Ventilago denticulata</i>.</p> <p>During the survey work two very important species of trees also have been found in Khatima and Surai range. <i>Carallia brachiata</i> (Lour.) Merr. is a fresh water mangrove species of the family Rhizophoraceae. In Uttarakhand the species only known from fresh water swamp of Nakronda near Dehradun in Garhwal Himalaya. The isolated tree has been found in Nakhatal block of Khatima range. While <i>Dillenia pentagyna</i> a Roxb. very useful tree commonly known as 'Dog Tree' located in two locations with one individuals in Surai range. The species is new record for Uttarakhand forest flora and earlier reported from adjoin forest area of Pilibhit Tiger Reserve and Dudhawa National park of Uttar Pradesh.</p>
<p>Uttarkashi: Uttarkashi Forest Division: Gangotri Forest Range (Nilang), Uttarkashi Ranges</p> <p>Trees: <i>Acer acuminatum</i>, <i>Acer caesium</i>, <i>Acer pictum</i>, <i>Acer oblongum</i>, <i>Albizia chinensis</i>, <i>Albizia procera</i>, <i>Alnus nepalensis</i>, <i>Betula utilis</i>, <i>Bombax ceiba</i>, <i>Cedrus deodara</i>, <i>Celtis tetrandra</i>, <i>Cinnamomum tamala</i>, <i>Engelhardtia spicata</i>, <i>Ficus auriculata</i>, <i>Ficus semicordata</i>, <i>Grewia optiva</i>, <i>Hymenodictyon excelsum</i>, <i>Juglans regia</i>, <i>Juniperus</i></p>

macropoda, *Kydia calycina*, *Pinus roxburghii*, *Pinus wallichiana*, *Populus ciliata*, *Prunus cornuta*, *Malus baccata*, *Melia azedarach*, *Myrica esculenta*, *Ougeinia oojeinensis*, *Rhododendron arboreum*, *Syzygium cumini*, *Terminalia chebula*, *Toona ciliata*, *Toona serrata*, *Quercus leucotrichophora* and *Ulmus wallichiana*.

Shrubs: *Phyllanthus embelica*, *Hippophae salicifolia* and *Prinsepia utilis*.

RET: *Caragana sukiensis*

Pithoragarh (Dharchula, Didihat, Askot Gangolihat and Pithoragarh) and Champawat Forest Division (Kalikumaon, Lohaghat and Champawat ranges):

Trees: *Abies spectabilis*, *Acer oblongum*, *Aesculus indica*, *Albizia chinensis*, *Albizia procera*, *Albizia lebbeck*, *Alnus nepalensis*, *Boehmeria rugulosa*, *Carpinus viminea*, *Cassia fistula*, *Cedrus deodara*, *Celtis tetrandra*, *Cinnamomum tamala*, *Cornuscapitata*, *Diospyros montana*, *Diploknema butyracea*, *Engelhardtia spicata*, *Erythrina suberosa*, *Ficus racemosa*, *Ficus rumphii*, *Ficus semicordata*, *Grewia optiva*, *Juglans regia*, *Litsea monopectela*, *Litsea chinensis*, *Machilus odoratissima*, *Mangifera indica*, *Mitragyna parvifolia*, *Myrica esculenta*, *Oroxylum indicum*, *Ougeinia oojeinensis*, *Pinus roxburghii*, *P. wallichiana*, *Prunus cerasoides*, *Quercus floribunda*, *Quercus glauca*, *Quercus leucotrichophora*, *Quercus semecarpifolia*, *Rhododendron arboreum*, *Sapium insigne*, *Sterculia villosa*, *Syzygium cumini*, *Terminalia arjuna*, *Terminalia bellirica*, *Toona ciliata*, *Toona serrata* and *Ziziphus mauritiana*

Shrubs: *Adhatoda vasica*, *Asparagus adscendens*, *Callicarpa macrophylla*, *Debregeasia saeneb*, *Elaeagnus latifolia*, *Helicteres isora*, *Indigofera cassioides*, *Catunaregam spinosa*, *Prinsepia utilis* and *Zanthoxylum armatum*

Climbers: *Chonemorpha macrophylla*, *Clematis gouriana* and *Stephania glabra*.

RET: *Cinnamomum glanduliferum* (Champawat Range), *Datisca cannabina* (Near Tapowan, Dharchula), *Indopiptadenia oudhensis* (Champawat), *Macranga pustulata* (Pithoragarh range), *Sterculia colorata* (Near Dharchula), *Neolitsea pallens* (Manch), *Uncaria pilosa* (Near Jalujibi), *Cyathea spinulosa* and *Ilex pseudo-odorata* (Shandev) and *Trachycarpus takil* (Near Thal)

Nainital [Ram Nagar Forest Division (Kaladungi, Dehchauri, Kotta and Kosi ranges) and West Tarai Forest Division (Ramnagar and South Jaspur ranges):

Trees: *Acacia nilotica* ssp. *indica*, *Acacia catechu*, *Adina cordifolia*, *Aegle marmelos*, *Albizia lebbeck*, *Albizia procera*, *Alstonia scholaris*, *Anogeissus latifolia*, *Bauhinia racemosa*, *Bauhinia semla*, *Bischofia javanica*, *Bombax ceiba*, *Bridelia retusa*, *Buchanania lanzan*, *Butea monosperma*, *Careya arborea*, *Cassia fistula*, *Celtis tetrandra*, *Citrus medica*, *Cordia dichotoma*, *Crateva adansonii* ssp. *odora*, *Dalbergia sissoo*, *Diospyros montana*, *Phyllanthus embelica*, *Erythrina suberosa*, *Ficus auriculata*, *Ficus bengalensis*, *Ficus racemosa*, *Ficus rumphii*, *Ficus semicordata*, *Grewia optiva*, *Hymenodictyon excelsum*, *Kydia calycina*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Litsea chinensis*, *Machilus duthiei*, *Madhuca longifolia*, *Mangifera indica*, *Melia azedarach*, *Mitragyna parvifolia*, *Ougeinia oojeinensis*, *Pinus roxburghii*, *Pterospermum acerifolium*, *Putranjiva roxburghii*, *Schleichera oleosa*, *Semecarpus anacardium*, *Shorea robusta*, *Syzygium cumini*, *Terminalia arjuna*, *Terminalia bellirica*, *Terminalia alata*, *Toona ciliata* and *Ziziphus mauritiana*.

Shrubs: *Adhatoda vasica*, *Asparagus adscendens* and *Callicarpa macrophylla*, *Catunaregam spinosa* and *Vitex negundo*.

Climbers: *Bauhinia vahlii*, *Celastrus paniculatus*, *Chonemorpha macrophylla*, *Clematis gouriana*, *Smilax ovalifolia* and *Cryptolepis buchananii*.

RET: *Gardenia turgida* and *Heteropanax fragrans*

Nainital (Nandhaur wildlife sanctuary, Nainital Forest Division, Haldwani Forest Division and Ramnagar Forest Division):

Trees: *Acer oblongum*, *Aesculus indica*, *Albizia lebbeck*, *Albizia procera*, *Acacia catechu*, *Adina cordifolia*, *Bauhinia semla*, *Bombax ceiba*, *Bauhinia racemosa*, *Bischofia*

javanica Ficus racemosa, Holoptelia integrifolia, Anogeissus latifolia, Trema orientalis, Toona ciliata, Litsea monopectata, Mangifera indica, Putranjiva roxburghii, Ougeinia oojainensis, Wendlandia heynei, Garuga pinnata, Shorea robusta, Terminalia alata, Terminalia bellirica, Hymenodictyon excelsum, Ficus rumphii, Ficus auriculata, Ficus semicordata, Olea paniculata, Lagerstroemia parviflora, Salix tetrasperma, Albizia odoratissima, Melia azedarach, Pinus roxburghii, Bridelia retusa, Buchanania lanzan, Schleicheria oleosa, Sapium insigne, Pistacia integerrima, Boehmeria rugulosa, Lannea coromandelica, Cinnamomum tamala, Machilus gamblei, Engelhardtia spicata, Machilus odoratissima, Populus ciliata, Fraxinus micrantha, Quercus floribunda, Myrica esculenta, Cornus capitata, Rhododendron arboreum, Prunus cerasoides, Betula alnoides, Quercus semicarpifolia, Quercus lanata, Carpinus viminea and Abies pindrow.

Shrubs: *Vitex negundo, Debregeasia saenab and Catunaregam spinosa.*

Climbers: *Bauhinia vahlii, Pueraria tuberosa, Ventilago denticulata and Cryptolepis buchananii etc.*

Rare: *Marsdenia lucida and Butea peltita.*

Uttarkashi: Tons Forest Division (Sandra and Purola ranges):

Trees: *Acer oblongum, Aesculus indica, Albizia chinensis, Bauhinia semla, Celtis australis, Celtis tetrandra, Albizia julibrissin, Cedrus deodara, Cornus capitata, Dalbergia sissoo, Ficus auriculata, Ficus neriifolia var. nemoralis, Ficus semicordata, Fraxinus micrantha, Grewia optiva, Hovenia dulcis, Hymenodictyon excelsum, Juglans regia, Machilus duthiei, Myrica esculenta, Pinus roxburghii, Pistacia integerrima, Populus ciliata, Phoenix humilis, Bombax ceiba, Punica granatum, Lannea coromandelica, Prunus cerasoides, Pyrus pashia, Quercus leucotrichophora, Rhododendron arboreum, Salix tetrasperma, Sapium insigne, Sterculia villosa, Toona ciliata, Toona serrata, Ficus virens, Mangifera indica and Ulmus wallichiana.*

Shrubs: *Phyllanthus embelica, Elaeagnus latifolia, Picrasma quassioides and Rhus parviflora.*

Climbers: *Pueraria tuberosa.*

Uttarkashi: Gobind Wildlife sanctuary (Rupin, Supin, Sankari Ranges):

Trees: *Abies pindrow, Abies spectabilis, Acer caesium, Betula alnoides, Aesculus indica, Alnus nepalensis, Betula utilis, Buxus wallichiana, Celtis australis, Ficus auriculata, Carpinus viminea, Quercus leucotrichophora, Quercus floribunda, Juglans regia, Corylus jacquemontii, Rhododendron arboreum, Cedrus deodara, Picea smithiana, Pinus wallichiana, Hovenia dulcis, Toona serrata, Elagnus latifolia, Quercus leucotrichophora, Cornus macrophylla, Populus ciliata and Picrasma quassioides.*

Shrubs: *Prinsepia utilis, Zanthoxylum armatum and Skimmia anquetilia*

Chamoli: Badrinath Forest Division (Nandprayag, East Pindar Ranges):

Trees: *Abies pindrow, Acer oblongum, Acer caesium, Aesculus indica, Acer sterculiaceum, Alnus nepalensis, Prunus cornuta, Betula alnoides, Betula utilis, Buxus wallichiana, Cupressus torulosa, Dodecadenia grandiflora, Juniperus macropoda, Pinus wallichiana, Albizia julibrissin, Bauhinia purpurea, Betula alnoides, Betula utilis, Carpinus viminea, Cedrus deodara, Daphniphyllum himalense, Juglans regia, Machilus odoratissima, Picea smithiana, Pinus roxburghii, Populus ciliata, Quercus leucotrichophora, Quercus floribunda, Quercus semicarpifolia, Rhododendron arboreum, Rhododendron arboreum, Toona serrata, Hippophae salicifolia, Pyrus pashia, Albizia chinensis, Celtis tetrandra, Ulmus wallichiana and Populus ciliata.*

Shrubs: *Berberis chitria, B. asiatica, B. lycium and Prinsepia utilis.*

RET: *Michelia kisopa and Fraxinus xanthoxyloides*

Chamoli: Nanda Devi Biosphere Reserve (Joshimath, Niti Ranges):

Trees: *Populus ciliata, Acer acuminatum, Cupressus torulosa, Abies pindrow, Abies spectabilis, Picea smithiana, Pinus wallichiana, Prunus cornuta, Fraxinus xanthoxyloides, Juglans regia, Cedrus deodara, Betula utilis, Quercus leucotrichophora etc.*

<p>Shrubs: <i>Ephedra gerardiana</i> and <i>Hippophae salicifolia</i></p>
<p>Chakrata Forest Division (Kanasar, Rikhnar, River Ranges): Trees: <i>Alnus nitida</i>, <i>Albizia chinensis</i>, <i>Buxus wallichiana</i>, <i>Abies pindrow</i>, <i>Picea smithiana</i>, <i>Picea smithiana Albizia julibrissin</i>, <i>Ficus auriculata</i>, <i>Ficus benghalensis</i>, <i>Ficus rumphii</i>, <i>Boehmeria rugulosa</i>, <i>Bombax ceiba</i>, <i>Ficus semicordata</i>, <i>Ficus racemosa</i>, <i>Olea cuspidata</i>, <i>Lannea coromandelica</i>, <i>Celtis australis</i>, <i>Myrica esculenta</i>, <i>Prunus cerasoides</i>, <i>Acer oblongum</i>, <i>Punica granatum</i>, <i>Acer acuminatum</i>, <i>Rhododendron arboreum</i>, <i>Cornus capitata</i>, <i>Cornus oblonga</i>, <i>Cornus macrophylla</i>, <i>Populus ciliata</i>, <i>Pinus roxburghii</i>, <i>Pinus wallichiana</i>, <i>Cedrus deodara</i>, <i>Shorea robusta</i>, <i>Cassia fistula</i>, <i>Terminalia bellirica</i>, <i>Holoptelea integrifolia</i>, <i>Bauhinia purpurea</i>, <i>Bauhinia semla</i>, <i>Phyllanthus emblica</i>, <i>Acacia catechu</i>, <i>Schleichera oleosa</i>, <i>Aegle marmelos</i>, <i>Adina cordifolia</i>, <i>Cupressus torulosa</i>, <i>Quercus floribunda</i>, <i>Quercus leucotrichophora</i>, <i>Quercus semicarpifolia</i>, <i>Taxus baccata</i>, <i>Juglans regia</i>, <i>Grewia optiva</i> and <i>Pyrus pashia</i> Shrubs: <i>Zanthoxylum armatum</i>, <i>Prinsepia utilis</i>, <i>Rubus ellipticus</i>, <i>Berberis lycium</i>, <i>Berberis asiatica</i>, <i>Ephedra gerardiana</i>, <i>Debregeasia saeneb</i> and <i>Pistacia integerrima</i> Climbers: <i>Bauhinia vahlii</i> and <i>Stephania glabra</i> RET Plant: <i>Ficus glaberrima</i> and <i>jausarensis</i></p>
<p>Valley of Flowers National Park including Gangharria and Gobind Ghat and Nanda Devi National Park: Trees: <i>Abies pindrow</i>, <i>Abies spectabilis</i>, <i>Betula alnoides</i>, <i>Betula utilis</i>, <i>Corylus jacquemontii</i>, <i>Picrasma quassioides</i>, <i>Stypha emoedi</i>, <i>Prunus cornuta</i>, <i>Taxus baccata</i>, <i>Picea smithiana</i> and <i>Aesculus indica</i>. Shrubs: <i>Hippophae salicifolia</i></p>
<p>Bageshwar Forest Division (Bageswar Range, Kapkot Range, Glacier range, Dharampur Range): Trees: <i>Cornus capitata</i>, <i>Grewia optiva</i>, <i>Albizia chinensis</i>, <i>Albizia procera</i>, <i>Bauhinia purpurea</i>, <i>Bauhinia semla</i>, <i>Betula alnoides</i>, <i>Alnus nepalensis</i>, <i>Boehmeria rugulosa</i>, <i>Bombax ceiba</i>, <i>Carpinus viminea</i>, <i>Celtis australis</i>, <i>Ficus auriculata</i>, <i>Phyllanthus embelica</i>, <i>Ficus neriifolia</i> var. <i>nemoralis</i>, <i>Ficus semicordata</i>, <i>Juglans regia</i>, <i>Pinus roxburghii</i>, <i>Pittosporum napaulense</i>, <i>Daphniphyllum himalense</i>, <i>Berberis chitria</i>, <i>Quercus lanata</i>, <i>Quercus leucotrichophora</i>, <i>Quercus semicarpifolia</i>, <i>Sapium insigne</i>, <i>Ougeinia oojenensis</i>, <i>Machilus gamblei</i>, <i>Morus alba</i>, <i>Engelhardtia spicata</i>, <i>Buxus wallichiana</i>, <i>Syzygium cumini</i>, <i>Melia azedarach</i>, <i>Cinnamomum tamala</i>, <i>Dalbergia sissoo</i>, <i>Diploknema butyracea</i>, <i>Myrica esculenta</i>, <i>Pistacia integerrima</i>, <i>Fraxinus micrantha</i>, <i>Taxus baccata</i>, <i>Machilus odoratissima</i>, <i>Cedrus deodara</i>, <i>Betula utilis</i>, <i>Abies pindrow</i>, <i>Abies spectabilis</i>, <i>Pinus wallichiana</i>, <i>Picea smithiana</i>, <i>Aesculus indica</i> and <i>Toona serrata</i>. Shrubs: <i>Vitex negundo</i> and <i>Zanthoxylum armatum</i> Climbers: <i>Cryptolepis buchananii</i> and <i>Stephania glabra</i>. RET: <i>Marsdenia lucida</i>.</p>
<p>Almora Forest Division (Binsar Wildlife sanctuary, Chakodi Rane): Trees: <i>Albizia julibrissin</i>, <i>Aesculus indica</i>, <i>Acer oblongum</i>, <i>Acer caesium</i>, <i>Acer acuminatum</i>, <i>Cedrus deodara</i>, <i>Quercus glauca</i>, <i>Quercus leucotrichophora</i>, <i>Ficus auriculata</i>, <i>Ficus neriifolia</i> var. <i>nemoralis</i>, <i>Populus ciliata</i>, <i>Toona serrata</i>, <i>Albizia julibrissin</i>, <i>Carpinus viminea</i>, <i>Cornus macrophylla</i>, <i>Cornus capitata</i>, <i>Machilus duthiei</i>, <i>Prunus cornuta</i>, <i>Daphniphyllum himalense</i>, <i>Cinnamomum tamala</i>, <i>Diploknema butyracea</i>, <i>Syzygium cumini</i>, <i>Mangifera indica</i>, <i>Hymenodictyon excelsum</i>, <i>Pistacia integerrima</i> and <i>Prunus cerasoides</i>.</p>
<p>Nainital: Ramnagar Forest Division (Mohan Range): Trees: <i>Cassia fistula</i>, <i>Holoptelia integrifolia</i>, <i>Sapium insigne</i>, <i>Adina cordifolia</i>, <i>Schleichera oleosa</i>, <i>Daphniphyllum himalense</i>, <i>Lagerstroemia parviflora</i>, <i>Terminalia</i></p>

tomentosa, *Careya arborea*, *Semecarpus anacardium*, *Anogeissus latifolia*, *Shorea robusta*, *Terminalia bellirica*, *Syzygium cumini*, *Ficus bengalensis* and *Ficus auriculata*.

Shrubs: *Adhatoda vasica*, *Asparagus adscendens* and *Catunaregam spinosa*.

Climbers: *Bauhinia vahlii*, *Celastrus paniculatus* and *Cryptolepis buchananii*.

Pithoragarh Forest Division (Munsiyari range, Thal Range):

Trees: *Abies pindrow*, *Acer caesium*, *Acer oblongum*, *Echinocarpus tomentosus*, *Tortellia tilifolia*, *Fraxinus micrantha*, *Acer acuminatum*, *Aesculus indica*, *Albizia chinensis*, *Neolitsea umbrosa*, *Alnus nepalensis*, *Betula utilis*, *Buxus wallichiana*, *Carpinus viminea*, *Cedrus deodara*, *Celtis tetrandra*, *Cupressus torulosa*, *Engelhardtia spicata*, *Ficus nervosa*, *Ficus semicordata*, *Machilus odoratissima*, *Buxus wallichiana*, *Myrica esculenta*, *Pinus roxburghii*, *Prunus cerasoides*, *Quercus floribunda*, *Quercus glauca*, *Q. leucotrichophora*, *Q. semicarpifolia*, *Rhododendron arboreum*, *Daphniphyllum himalense*, *Macranga pustulata*, *Dodecadenia grandiflora*, *Rhododendron arboretum*, *Quercus semicarpifolia*, *Macranga indica* and *Saurauia napaulensis*.

RET: *Trachycarpus takil* and *Dodecadenia grandiflora*

Uttarkashi Forest Division (Gangotri, Batwari, Dunda, Dharasu and Badahat Forest Ranges):

Trees: *Pinus wallichiana*, *Pinus roxburghii*, *Alnus nepalensis*, *Acer caesium*, *Acer oblongum*, *Quercus leucotrichophora*, *Albizia chinensis*, *Pyrus pashia*, *Abies spectabilis*, *Aesculus indica*, *Acer sterculiaceum*, *Bauhinia purpurea*, *Betula alnoides*, *Betula utilis*, *Carpinus viminea*, *Cedrus deodara*, *Picea smithiana*, *Rhododendron arboreum*, *Taxus baccata*, *Toona serrata*, *Quercus semicarpifolia*, *Quercus lanata*, *Berberis chitria*, *Albizia lebbeck*, *Sapium insigne*, *Hymenodictyon excelsum*, *Phyllanthus embelica*, *Ficus auriculata*, *Ficus semicordata*, *Juniperus macropoda*, *Salix tetrasperma*, *Engelhardtia spicata*, *Mangifera indica*, *Myrica esculenta*, *Ougeinia oojeinensis*, *Bauhinia semla*, *Lannea coromandelica*, *Cinnamomum tamala*, *Wendlandia heynei*, *Cupressus torulosa*, *Corylus jacquemontii*, *Ficus rumphii*, *Prunus cerasoides*, *Quercus floribunda* and *Trema orientalis*.

Shrubs: *Callicarpa macrophylla*, *Debregeasia saeneb*, *Hippophae salcifolia*, *Phoenix humilis*, *Prinsepia utilis*, *Rhus parviflora*, *Phyllanthus embelica*, *Smilax osmastonii* and *Zanthoxylum armatum*.

Climbers: *Bauhinia vahlii* and *Cryptolepis buchananii*.

RET: *Caragana sukiensis*

Mussoorie Forest Division (Mussoorie, Janpur, Kempty, Bhadrigadand Raipur Ranges):

Trees: *Shorea robusta*, *Syzygium cumini*, *Abies pindrow*, *Bauhinia semla*, *Gmelina arborea*, *Olea glandulifera*, *Machilus duthiei*, *Rhododendron arboreum*, *Acer caesium*, *Pistacia integerrima*, *Celtis tetrandra*, *Celtis australis*, *Sapium insigne*, *Cedrus deodara*, *Quercus floribunda*, *Cornus macrophylla*, *Cornus capitata*, *Cornus oblonga*, *Juglans regia*, *Quercus lanata*, *Populus ciliata*, *Quercus leucotrichophora*, *Cinnamomum tamala*, *Ficus semicordata*, *Ficus neriifolia* var. *nemoralis*, *Lannea coromandelica*, *Ficus auriculata*, *Ougeinia oojeinensis*, *Grewia optiva*, *Kydia calycina*, *Bridelia retusa*, *Flacourtia jangomas*, *Phyllanthus embelica*, *Machilus duthiei*, *Prunus cerasoides*, *Engelhardtia spicata*, *Holoptelea integrifolia*, *Terminalia bellirica*, *Bishcofia javanica*, *Moringa oleifera*, *Premna latifolia*, *Cassine glaucum*, *Anogeissus latifolia*, *Dalbergia sissoo*, *Bauhinia variegata*, *Trema orientalis*, *Pyrus pashia*, *Pinus wallichiana*, *Litsea lanuginosa*, *Myrica esculenta*, *Buxus wallichiana*, *Toona ciliata*, *Leucomeris spectabilis*, *Boehmeria rugulosa*, *Dalbergia sissoo*, *Wendlandia heynei*, *Acacia catechu*, *Ziziphus mauritiana*, *Tamarindus indica*, *Aegle marmelos*, *Melia azedarach*, *Albizia procera*, *Anogeissus latifolia* etc.

Shrubs: *Berberis asiatica*, *Berberis chitria*, *Asparagus adscendens*, *Debregeasia saeneb*, *Prinsepia utilis*, *Rhus parviflora* and *Zanthoxylum armatum*.

Climbers: *Bauhinia vahlii* and *Cryptolepis buchananii*.

RET: *Brassaiopsis aculeata*

Haridwar Forest Division (Haridwar, Shyampur Range, Chidiapur and Jhilmiljheel range)

Trees: *Acacia catechu*, *Acacia nilotica* ssp. *indica*, *Acacia pseudo-eburnea*, *Adina cordifolia*, *Aegle marmelos*, *Alangium salviifolium*, *Alstonia scholaris*, *Albizia lebbeck*, *Albizia chinensis*, *Albizia procera*, *Albizia odoratissima*, *Anogeissus latifolia*, *Ailanthus excelsa*, *Azadirachta indica*, *Bauhinia semla*, *Bauhinia racemosa*, *Bauhinia variegata*, *Bombax ceiba*, *Boswellia serrata*, *Boehmeria rugulosa*, *Bridelia retusa*, *Buchanania lanzan*, *Butea monosperma*, *Butea monosperma*, *Cassia fistula*, *Cordia dichotoma*, *Crateva adansonii*, *Careya arborea*, *Cassine glauca*, *Dalbergia lanceolaria*, *Dalbergia sissoo*, *Erythrina suberosa*, *Ficus benghalensis*, *Ficus rumphii*, *Ficus semicordata*, *Ficus benghalensis*, *Ficus racemosa*, *Garuga pinnata*, *Grewia oppositifolia*, *Grewia optiva*, *Gmelina arborea*, *Holoptelia integrifolia*, *Hymenodictyon excelsum*, *Kydia calycina*, *Litsea monopectala*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Machilus gamblei*, *Mangifera indica*, *Melia azedarach*, *Miliusa velutina*, *Mitragyna parvifolia*, *Oroxylum indicum*, *Ougeinia oojeinensis*, *Pyrus pashia*, *Premna latifolia*, *Pinus roxburghii*, *Putranjiva roxburghii*, *Phyllanthus embelica*, *Pterospermum acerifolium*, *Sapium insigne*, *Schleichera oleosa*, *Shorea robusta*, *Stereospermum chelonoides*, *Sterculia villosa*, *Terminalia alata*, *Terminalia chebula*, *Terminalia bellerica*, *Trema orientalis*, *Wrightia arborea*, *Wendlandia heynei*, *Ziziphus mauritiana* and *Ziziphus xylopyrus*, *Catunaregam spinosa*,

Shrubs: *Adhatoda vasica*, *Asparagus adscendens*, *Helicteres isora*, *Catunaregam spinosa*, *Phoenix humilis*, *Vitex negundo* and *Ziziphus xylopyra*.

Climber: *Clematis gouriana*, *Bauhinia vahlii*, *Calamus tenuis* and *Cryptolepis buchananii*.

RET: *Cochlospermum religiosum* and *Catamixis baccharoides*

Haridwar: Rajaji Tiger Researve (Haridwar, Motichur, Kansro Ramgarh, Chila Ranges):

Trees: *Anogeissus latifolia*, *Adina cordifolia*, *Ailanthus grandis*, *Aegle marmelos*, *Albizia procera*, *Albizia odoratissima*, *Albizia lebbeck*, *Bombax ceiba*, *Bridelia retusa*, *Bauhinia racemosa*, *Butea monosperma*, *Buchanania lanzan*, *Careya arborea*, *Cassia fistula*, *Cordia dichotoma*, *Diospyros cordifolia*, *Phyllanthus embelica*, *Ficus benghalensis*, *Ficus rumphii*, *Holoptelea integrifolia*, *Lannea coromandelica*, *Lagerstroemia parviflora*, *Litsea monopetala*, *Machilus gamblei*, *Mangifera indica*, *Melia azedarach*, *Madhuca indica*, *Mitragyna parvifolia*, *Sapium sebiferum*, *Schleichera oleosa*, *Shorea robusta*, *Syzygium cumini*, *Terminalia alata*, *Terminalia bellirica*, *Terminalia chebula*, *Toona ciliata*, *Wrightia arborea* and *Ziziphus mauritiana*.

Shrub: *Vitex negundo*,

Climber: *Cryptolepis buchanani*

RET: *Gardenia turgid*, *Cochlospermum religiosum*

Narendra Nagar Forest Division (Rishikesh & Narendra Nagar ranges)

Trees: *Acacia catechu*, *Adina cordifolia*, *Aegle marmelos*, *Anogeissus latifolia*, *Buchanania lanzan*, *Butea monosperma*, *Bombax ceiba*, *Cassia fistula*, *Cassine glauca*, *Dalbergia lanceolaria*, *Ficus religiosa*, *Ficus rumphii*, *Gmelina arborea*, *Holoptelea integrifolia*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Mangifera indica*, *Mitragyna parvifolia*, *Phyllanthus embelica*, *Sapium insigne*, *Schleichera oleosa*, *Shorea robusta*, *Terminalia alata*, *Terminalia bellirica*, *Wendlandia heynei* and *Ziziphus mauritiana*.

Shrubs: *Adhatoda vasica*

Climber: *Bauhinia vahlii*

Udham Singh Nagar and and Nainital (Tarai Central Forest Division, Ramnagar

<p>Forest Division): Trees: <i>Acacia catechu</i>, <i>Adina cordifolia</i>, <i>Aegle marmelos</i>, <i>Alangium salviifolium</i>, <i>Albizia procera</i>, <i>Anogeissus latifolia</i>, <i>Alstonia scholaris</i>, <i>Azadirachta indica</i>, <i>Bombax ceiba</i>, <i>Bauhinia racemosa</i>, <i>Buchanania lanzan</i>, <i>Callicarpa arborea</i>, <i>Cassia fistula</i>, <i>Holoptelea integrifolia</i>, <i>Hymenodictyon excelsum</i>, <i>Lannea coromandelica</i>, <i>Lagerstroemia parviflora</i>, <i>Litsea chinensis</i>, <i>Moringa oleifera</i>, <i>Ougeinia oojeinensis</i>, <i>Oroxylum indicum</i>, <i>Persea gamblei</i>, <i>Phyllanthus embelica</i>, <i>Putranjiva roxburghii</i>, <i>Catunaregam dumetorum</i>, <i>Sapium insigne</i>, <i>Shorea robusta</i>, <i>Stereospermum chelonoides</i>, <i>Syzygium cumini</i>, <i>Terminalia alata</i>, <i>Terminalia bellirica</i>, <i>Toona ciliata</i>, <i>Trema orientalis</i> and <i>Wendlandia heynei</i>, Shrubs: <i>Vitex negundo</i>, <i>Colebrookea oppositifolia</i> and <i>Ziziphus mauritiana</i>. Climber: <i>Bauhinia vahlii</i></p>
<p>Landsdown Forest Division (Laldhang, Lansdowne and Duggadda Range): Trees: <i>Acacia catechu</i>, <i>Acer oblongum</i>, <i>Adina cordifolia</i>, <i>Aegle marmelos</i>, <i>Albizia procera</i>, <i>Anogeissus latifolia</i>, <i>Bauhinia racemosa</i>, <i>Bauhinia semla</i>, <i>Boehmeria rugulosa</i>, <i>Bombax ceiba</i>, <i>Bridelia retusa</i>, <i>Butea monosperma</i>, <i>Careya arborea</i>, <i>Cassia fistula</i>, <i>Cassine glauca</i>, <i>Celtis tetrandra</i>, <i>Cordia dichotoma</i>, <i>Crateva adansonii</i> ssp. <i>odora</i>, <i>Diospyros montana</i>, <i>Phyllanthus embelica</i>, <i>Erythrina suberosa</i>, <i>Ficus auriculata</i>, <i>Ficus bengalensis</i>, <i>Ficus racemosa</i>, <i>Ficus rumphii</i>, <i>Ficus semicordata</i>, <i>Ficus virens</i>, <i>Grewia optiva</i>, <i>Holoptelia integrifolia</i>, <i>Hymenodictyon excelsum</i>, <i>Kydia calycina</i>, <i>Lagerstroemia parviflora</i>, <i>Lannea coromandelica</i>, <i>Mangifera indica</i>, <i>Mitragyna parvifolia</i>, <i>Myrica esculenta</i>, <i>Oroxylum indicum</i>, <i>Ougeinia oojeinensis</i>, <i>Pinus roxburghii</i>, <i>Putranjiva roxburghii</i>, <i>Quercus leucotrichophora</i>, <i>Rhododendron arboretum</i>, <i>Sapium insigne</i>, <i>Schleichera oleosa</i>, <i>Semecarpus anacardium</i>, <i>Shorea robusta</i>, <i>Sterculia villosa</i>, <i>Syzygium cumini</i>, <i>Tamarindus indica</i>, <i>Terminalia bellirica</i>, <i>Terminalia tomentosa</i>, <i>Toona ciliata</i>, <i>Phyllanthus embelica</i>, <i>Alstonia scholaris</i>, <i>Dalbergia lanceolaria</i>, <i>Engelhardtia spicata</i> and <i>Pterospermum acerifolium</i>. Shrubs: <i>Ziziphus mauritiana</i>, <i>Catunaregam spinosa</i>, <i>Rhus parviflora</i>, <i>Sophora mollis</i>, <i>Helicteres isora</i>, <i>Phoenix humilis</i> and <i>Berberis asiatica</i>. Climbers: <i>Celastrus paniculatus</i>, <i>Cryptolepis buchananii</i> and <i>Bauhinia vahlii</i>.</p>
<p>Tehari Garhwal: Tehari Dam Forest Division: Trees: <i>Rhododendron arboreum</i>, <i>Quercus leucotrichophora</i>, <i>Betula alnoides</i>, <i>Machilus odoratissima</i>, <i>Aegle marmelos</i>, <i>Grewia optiva</i>, <i>Engelhardtia spicata</i>, <i>Pistacia integerrima</i>, <i>Cassine glauca</i> and <i>Phyllanthus embelica</i>. Shrubs: <i>Rhus parviflora</i></p>
<p>Tehari Garhwal: Tehri Forest Division (Bhilgana Range, Nailchami Dam Range, Chamba) Trees: <i>Acacia catechu</i>, <i>Albizia lebeck</i>, <i>Bauhinia semla</i>, <i>Bauhinia variegata</i>, <i>Bombax ceiba</i>, <i>Cedrus deodara</i>, <i>Engelhardtia spicata</i>, <i>Dalbergia lanceolaria</i>, <i>Terminalia tomentosa</i>, <i>Cassia fistula</i>, <i>Ficus auriculata</i>, <i>Pistacia integerrima</i>, <i>Celtis australis</i>, <i>Celtis tetrandra</i>, <i>Pinus roxburghii</i>, <i>Alnus nepalensis</i>, <i>Quercus leucotrichophora</i>, <i>Prunus cerasoides</i>, <i>Lannea coromandelica</i>, <i>Toona ciliata</i>, <i>Bauhinia variegata</i>, <i>Bauhinia semla</i>, <i>Albizia chinensis</i>, <i>Ougeinia oojeinensis</i>, <i>Sterculia villosa</i>, <i>Cinnamomum tamala</i>, <i>Litsea monoptela</i> and <i>Punica granatum</i>. Shrubs: <i>Berberis asiatica</i>, <i>Phyllanthus embelica</i>, <i>Asparagus adscendens</i>, <i>Debregeasia saeneb</i>, <i>Zanthoxylum armatum</i> and <i>Rhus parviflora</i>. Climbers: <i>Cryptolepis buchananii</i>, <i>Hiptage benghalensis</i>, <i>Celastrus paniculatus</i> and <i>Pueraria tuberosa</i>.</p>
<p>Uttarkashi: Uttarkashi Forest Division (Kot Bangla Range): Trees: <i>Pittosporum napaulense</i>, <i>Buxus wallichiana</i>, <i>Alnus nepalensis</i>, <i>Pinus wallichiana</i>, <i>Rhododendron arboreum</i>, <i>Aesculus indica</i>, <i>Acer caesium</i>, <i>Quercus leucotrichophora</i>, <i>Toona serrata</i>, <i>Ulmus wallichiana</i>, <i>Fraxinus macarantha</i>, <i>Cedrus deodara</i>, <i>Juglans regia</i>, <i>Cupressus torrulosa</i> and <i>Neolitsea umbrosa</i>.</p>

<p>Shrubs: <i>Hippophae salicifolia</i></p>
<p>Uttarkashi: Upper Yamuna Forset Division (Naugaon, Kuthnour, Yumnutri Ranges) Trees: <i>Acer caesium, Acer sterculiaceum, Albizia chinensis, Dalbergia sissoo, Juglans regia, Alnus nepalensis, Bauhinia purpurea, Betula alnoides, Rhododendron arboreum, Euonymus tingens, Celtis tetrandra, Rhododendron arboreum, Ficus auriculata, Quercus leucotrichophora, Quercus floribunda, Quercus semecorpifolia, Abies pindrow, Picea smithiana, Taxus baccata and Pinus wallichiana</i></p>
<p>Dehradun Forest Division (Thano, Malsi, Lacchiwala Ranges, Jhajra and Badkot Ranges): Trees: <i>Acacia catechu, Aegle marmelos, Adina cordifolia, Anogeissus latifolia, Semecarpus anacardium, Azadirachta indica, Bauhinia semla, Bauhinia racemosa, Bischofia javanica, Bombax ceiba, Bridelia retusa, Butea monosperma, Dalbergia lanceolaria, Cordia dichotoma, Dalbergia sissoo, Erythrina suberosa, Grewia optiva, Lannea coromandelica, Litsea monopectala, Machilus duthiei, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia jangomas, Lagerstroemia parviflora, Oroxylum indicum, Kydia calycina, Ficus benghalensis, Schleicheria oleosa, Terminalia bellirica, Hymenodictyon excelsum, Albizia lebbeck, Cassia fistula, Shorea robusta, Holoptelea integrifolia, Sterculia villosa, Syzygium cumini, Wendlandia heynei, Laucomeris spectabilis, Sapium insigne, Boehmeria rugulosa, Toona ciliata, Albizia procera, Syzygium cumini, Ziziphus rugosa, Calamus tenuis, Cassine glauca, Phyllanthus emblica, Litsea monopetala, Premna latifolia, Cordia dichotoma, Terminalia alata, Syzygium cumini, Ficus racemosa, Mangifera indica,</i> Shrubs: <i>Calamus tenuis, Debregeasia saeneb, Catunaregam spinosa and Adhatoda vasica, Helictis isora, Phlogacanthus thyrsoformis</i> Climbers: <i>Bauhinia vahlii</i> RET: <i>Acronychia pedunculata, Carallia brachiata, Dryptis assamicus, and Ficus glaberrima.</i></p>
<p>Rudraprayag: Rudraprayag Forest Division (South and North Jakholi Forest Range, Rudraprayag Forest Range, Khankra Range, Karnprayag): Trees: <i>Aegle marmelos, Alnus nepalensis, Anogeissus latifolia, Bauhinia purpurea, Bridelia retusa, Bauhinia variegata, Betula alnoides, Bombax ceiba, Boehmeria rugulosa, Butea monosperma, Cassia fistula, Cassine glauca, Celtis australis, Cupressus torulosa, Cinnamomum tamala, Dalbergia lanceolaria, Grewia optiva, Ficus semicordata, Phyllanthus emblica, Engelhardtia spicata, Ficus racemosa, Ficus neriifolia var. nemoralis, Ficus bengalensis, Ficus auriculata, Flacourtia jangomas, Quercus floribunda, Quercus semicarpifolia, Quercus leucotrichophora, Kydia calycina, Lannea coromandelica, Mangifera indica, Myrica esculenta, Pistacia integerrima, Rhododendron arboreum, Trema orientalis, Premna latifolia, Ougeinia oojeinensis, Oroxylum indicum, Picea smithiana, Prunus cerasoides, Sapium insigne, Terminalia chebula, Toona ciliata, Punica granatum, Taxus baccata, Terminalia alata and Wrightia arborea.</i> Shrubs: <i>Asparagus adscendens Adhatoda vasica, Berberis asiatica, Berberis chitria, Prinsepia utilis, Phoenix humilis, Zanthoxylum armatum, Rhus parviflora, Vitex negundo and Catunaregam spinosa.</i> Climbers: <i>Bauhinia vahlii, Cryptolepis buchananii Hiptage benghalensis and Celastrus paniculatus.</i></p>
<p>Rudraprayag: Kedarnath Wildlife Sanctuary Forest Division (Ukhimath Range, including Chopta, Tungnath, Dhanpur Range (Gauchar): Trees: <i>Alnus nepalensis, Acer sterculiaceum, Betula alnoides, Bombax ceiba, Cinnamomum tamala, Ficus racemosa, Grewia optiva, Lannea coromandelica,</i></p>

<p><i>Daphniphyllum himalayense</i>, <i>Neolitsea cuipala</i>, <i>Machilus duthiei</i>, <i>Mangifera indica</i>, <i>Ficus auriculata</i>, <i>Juglans regia</i>, <i>Ougeinia oojeinensis</i>, <i>Pinus roxburghii</i>, <i>Toona ciliata</i>, <i>Myrica esculenta</i>, <i>Quercus floribunda</i>, <i>Quercus leucotrichophora</i>, <i>Picea smithiana</i>, <i>Quercus semicarpifolia</i>, <i>Rhododendron arboreum</i></p> <p>Shrubs: <i>Berberis asiatica</i>, <i>Adhatoda vasica</i>, <i>Calotropis gigantea</i>, <i>Debregeasia saeneb</i>, <i>Phoenix humilis</i>, <i>Rhus parviflora</i> and <i>Skimmia anquiltia</i>.</p> <p>RET: <i>Marsdenia lucida</i></p>
<p>Chamoli: Badrinath Forest Division (Nand Prayag Forest Range):</p> <p>Trees: <i>Pinus roxburghii</i>, <i>Phyllanthus embelica</i>, <i>Grewia optiva</i>, <i>Mangifera indica</i>, <i>Engelhardtia spicata</i>, <i>Syzygium cumini</i>, <i>Albizia lebbeck</i>, <i>Toona ciliata</i>, <i>Bombax ceiba</i>, <i>Melia azedarach</i>, <i>Bauhinia purpurea</i>, <i>Alnus nepalensis</i>, <i>Lannea coromandelica</i>, <i>Bridelia retusa</i>, <i>Punica granatum</i>, <i>Ficus semicordata</i>, <i>Premna latifolia</i>, <i>Pistacia integerrima</i>, <i>Pyrus pashia</i> and <i>Butea monosperma</i>.</p> <p>Shrubs: <i>Phoenix humilis</i>, <i>Berberis asiatica</i>, <i>Berberis chitria</i>, <i>Rhus parviflora</i>, <i>Catunaregam spinosa</i>, <i>Hiptage benghalensis</i> and <i>Vitex negundo</i>.</p> <p>Climbers: <i>Pueraria tuberosa</i></p>
<p>Chamoli: Alaknanda Soil Conservation Forest Division (Gopeshwar Range, Patiyaldhar):</p> <p>Trees: <i>Alnus nepalensis</i>, <i>Celtis australis</i>, <i>Carpinus viminea</i>, <i>Cinnamomum tamala</i>, <i>Cupressus torulosa</i>, <i>Daphniphyllum himalayense</i>, <i>Myrica esculenta</i>, <i>Pistacia integerrima</i>, <i>Lannea coromandelica</i>, <i>Phyllanthus embelica</i>, <i>Sapium insigne</i>, <i>Bombax ceiba</i>, <i>Ficus auriculata</i>, <i>Ficus racemosa</i>, <i>Ficus semicordata</i>, <i>Toona ciliata</i>, <i>Dalbergia sissoo</i>, <i>Premna latifolia</i>, <i>Albizia lebbeck</i>, <i>Betula alnoides</i>, <i>Bauhinia purpurea</i>, <i>Engelhardtia spicata</i>, <i>Bridelia retusa</i>, <i>Ougeinia oojeinensis</i>, <i>Quercus leucotrichophora</i>, <i>Pinus roxburghii</i>, <i>Cedrus deodara</i>, <i>Juglans regia</i>, <i>Ficus neriifolia</i> var. <i>nemoralis</i>, <i>Albizia lebbeck</i>, <i>Bauhinia variegata</i>, <i>Populus ciliata</i>, <i>Melia azedarach</i>, <i>Albizia julibrissin</i> and <i>Grewia optiva</i>.</p> <p>Shrubs: <i>Berberis asiatica</i>, <i>Phyllanthus embelica</i>, <i>Zanthoxylum armatum</i>, <i>Vitex negundo</i>, <i>Phoenix humilis</i> and <i>Debregeasia saeneb</i>.</p> <p>Climbers: <i>Hiptage benghalensis</i></p>
<p>Pithoragarh Forest Division: Dharchula Range:</p> <p>Trees: <i>Tsuga dumosa</i>, <i>Quercus lanata</i>, <i>Q. leucotrichophora</i>, <i>Betula utilis</i>, <i>Taxus baccata</i>, <i>Alangium salviifolium</i>, <i>Abies pindrow</i>, <i>Rhododendron arboreum</i>, <i>Prunus undulatum</i>, <i>Pinus wallichiana</i>, <i>Engelhardtia spicata</i>, <i>Alnus nepalensis</i>, <i>Machilus odoratissima</i>, <i>Populus ciliata</i> and <i>Macaranga pustulata</i>.</p> <p>Shrubs: <i>Berberis lycium</i> and <i>B. coriaria</i></p>
<p>Uttarkashi: Gangotri National Park, Batwari Range:</p> <p>Trees: <i>Alnus nepalensis</i>, <i>Acer oblongum</i>, <i>A. caesium</i>, <i>A. sterculiaceum</i>, <i>Aesculus indica</i>, <i>Albizia chinensis</i>, <i>A. lebbeck</i>, <i>Abies spectabilis</i>, <i>Bauhinia purpurea</i>, <i>Betula utilis</i>, <i>B. alnoides</i>, <i>Carpinus viminea</i>, <i>Cedrus deodara</i>, <i>Picea smithiana</i>, <i>Quercus semicarpifolia</i>, <i>Q. lanata</i>, <i>Q. leucotrichophora</i>, <i>Rhododendron arboreum</i>, <i>Taxus baccata</i>, <i>Toona serrata</i>, <i>Sapium insigne</i>, <i>Fraxinus macarantha</i>, <i>Juniperus macropoda</i>, <i>Salix tetrasperma</i>, <i>Pyrus pashia</i>, <i>Pinus wallichiana</i>, <i>P. roxburghii</i>, <i>Myrica esculenta</i>, <i>Cinnamomum tamala</i>, <i>Cupressus torulosa</i>, <i>Corylus jacquemontii</i> and <i>Prunus cerasoides</i>.</p> <p>Shrubs: <i>Berberis chitria</i>, <i>B. lycium</i>, <i>Callicarpa macrophylla</i>, <i>Debregeasia saeneb</i>, <i>Hippophae salicifolia</i>, <i>Phoenix humilis</i>, <i>Prinsepia utilis</i>, <i>Rhus parviflora</i>, <i>Smilax osmastonii</i> and <i>Zanthoxylum armatum</i> etc.</p> <p>Climbers: <i>Bauhinia vahlii</i> and <i>Cryptolepis buchananii</i></p>
<p>Kalagarh Tiger Reserve:</p> <p>Trees: <i>Acacia catechu</i>, <i>Acer oblongum</i>, <i>Adina cordifolia</i>, <i>Aegle marmelos</i>, <i>Albizia procera</i>, <i>Anogeissus latifolia</i>, <i>Bauhinia racemosa</i>, <i>Boehmeria rugulosa</i>, <i>Bombax ceiba</i>, <i>Bridelia retusa</i>, <i>Careya arborea</i>, <i>Cassia fistula</i>, <i>Erythrina suberosa</i>, <i>Ficus auriculata</i>, <i>Ficus bengalensis</i>, <i>Ficus racemosa</i>, <i>Ficus rumphii</i>, <i>Ficus semicordata</i>, <i>Ficus virens</i></p>

Holoptelia integrifolia, *Hymenodictyon excelsum*, *Kydia calycina*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Litsea monopectata*, *Mangifera indica*, *Oroxylum indicum*, *Ougeinia oojeinensis*, *Pinus roxburghii*, *Quercus leucotrichophora*, *Sapium insigne*, *Semecarpus anacardium*, *Shorea robusta*, *Syzygium cumini*, *Terminalia bellirica*, *Terminalia alata* and *Toona ciliata*.
Shrubs: *Adhatoda vasica*, *Callicarpa macrophylla*, *Helicteres isora* and *Rhus parviflora*

d) Study on Regeneration status

During survey several species were enumerated and regeneration status of following FGR species was studied using the Quadrant sampling method and quantitative analysis of vegetation for regeneration studies.

Table 10: Details of the species studied for regeneration status

Forest Division	Range	Species under regeneration status study
Uttarkashi Forest Division	Batwari	<i>Betula utilis</i> , <i>Hippophae salicifolia</i> , <i>Pinus wallichiana</i> , <i>Taxus baccata</i> , <i>Abies pindrow</i>
	Dharasu	<i>Cassia fistula</i>
	Dunda	<i>Bombax ceiba</i> , <i>Bahunia semla</i>
	Taknaur	<i>Aesculus indica</i> , <i>Rhododendron arboreum</i>
	Gangotri	<i>Picea smithiana</i>
Champawat Forest Division		<i>Diploknema butyracea</i> , <i>Aesculus indica</i> , <i>Myrica esculenta</i> , <i>Quercus glauca</i> , <i>Adina cordifolia</i> , <i>Anogeissus latifolia</i> , <i>Lannea coromandelica</i> , <i>Quercus leucotrichophora</i> , <i>Quercus lanuginosa</i> , <i>Litsea monopetala</i> , <i>Aesculus indica</i> and <i>Albizia julibrissin</i> , <i>Phyllanthus emblica</i>
	Tanakpur	<i>Anogeissus latifolia</i> , <i>Celtis australis</i>
	Kali Kumaon	<i>Bauhinia semla</i> , <i>Albizia chinensis</i> , <i>Albizia lebbek</i>
	Lohaghat	<i>Aesculus indica</i> , <i>Celtis tetrandra</i> , <i>Rhododendron arboreum</i> , <i>Salix tetrasperma</i> , <i>Flacourtia jangomas</i>
Kedarnath Wildlife Sanctuary		<i>Daphniphyllum himalayense</i> , <i>Rhododendron arboreum</i> , <i>Betula alnoides</i> , <i>Quercus leucotrichophora</i> , <i>Myrica esculenta</i>
	Ukhimath	<i>Acer caesium</i> , <i>Abies pindrow</i> , <i>Acer sterculiaceum</i> , <i>Cinnamomum tamala</i> , <i>Alnus nepalensis</i>
	Chopta	<i>Abies spectabilis</i> , <i>Picea smithiana</i>
	Gopeshwar	<i>Machilus odoratissima</i>
Badrinath Forest Division	Chamoli	<i>Aegle marmelos</i>
Nandhaur Wildlife sanctuary		<i>Bischofia javanica</i> , <i>Garunga pinnata</i> , <i>Holoptelia integrifolia</i>
	Danda	<i>Bischofia javanicain</i>
Haldwani forest Division		<i>Pterocarpus marsupium</i> , <i>Dysoxylum binectariferum</i> , <i>Syzygium cumini</i> , <i>Terminalia bellirica</i> , <i>Ficus racemosa</i> , <i>Aegle marmelos</i> , <i>Careya arborea</i> , <i>Schleichera oleosa</i>
Pithoragarh forest Division		<i>Tortellia tilifolia</i> , <i>Daphniphyllum himalayense</i> , <i>Macranga pustulata</i> , <i>Rhododendron arboreum</i> , <i>Dodecadenia grandiflora</i> , <i>Quercus semicarpifolia</i> , <i>Buxus wallichiana</i>
	Ghat	<i>Boehmeria rugulosa</i> , <i>Celtis tetrandra</i>
	Didihat	<i>Betula alnoides</i> , <i>Alnus nepalensis</i>
	Dharchula	<i>Albizia chinensis</i> , <i>Oroxylum indicum</i>
Joshimath Forest Division	Joshimath	<i>Betula alnoides</i>

Lansdowne Forest Division		<i>Crateva adansonii ssp. odora, Terminalia bellirica, Acer oblongum, Bauhinia racemosa, Quercus leucotrichophora, Careya arborea, Pinus roxburghii, Shorea robusta</i>
Kalagarh Tiger Researve		<i>Semecarpus anacardium, Pinus roxburghii, Shorea robusta</i>
Chakrata Forest Division		<i>Cedrus deodara, Quercus leucotrichophora, Myrica esculenta</i>
	Molta	<i>Albizza julibrissin</i>
	Deogarh	<i>Prinsepia utilis, Olea cuspidata</i>
Ramnagar Forest Division		<i>Aegle marmelos, Acacia catechu</i>
	Kosi	<i>Alstonia scholaris, Anogeissus latifolia, Litsaea glutinosa, Madhuca longifolia</i>
	Dehchauri	<i>Anogeissus latifolia, Schleicheria oleosa, Phlogacanthus thyriflorus, Schleicheria oleosa, Moringa pterygosperma, Lagerstroemia parviflora</i>
	Kota	<i>Butea monosperma, Celtis tetrandra</i>
	Kaladhungi	<i>Catunaregam spinosa, Schleicheria oleosa, Moringa pterygosperma, Lagerstroemia parviflora</i>
Haldwani Forest Division	Chakrata	<i>Cassine glauca</i>
Nainital Forest Division		<i>Acer oblongum, Abies spectabilis, Abies pindrow,</i>
	Naina	<i>Carpinus viminea</i>
	Kilbari	<i>Cornus capitata</i>
	Manora	<i>Boehmeria rugulosa, Machilus odoratissima</i>
	Dogaon	<i>Machilus gamblei</i>
Binsar wildlife sanctuary		<i>Albizza julibrissin, Acer oblongum, Adina cordifolia, Rhus parviflora</i>
Rajaji National Park		<i>Alangium salviifolium, Acronechia pedunculata, Ziziphus xylopyra, Sterculia villosa</i>
	Mansa Devi	<i>Boswellia serrata, Flacourtia jangomas, Holoptelia integrifolia</i>
	Tilwadi	<i>Bridelia retusa, Dalbergia lanceolaria</i>
	Shyampur	<i>Crateva adansonii ssp. Odora, Schleicheria oleosa, Mitragyna parvifolia, Garunga pinnata, Lagerstroemia parviflora</i>
	Kansro	<i>Butea monosperma</i>
	Mayapuri west	<i>Buchanania lanzan, Bridelia retusa, Anogeissus latifolia</i>
	Motichur Range	<i>Oroxylum indicum</i>
Bageshwar Forest Division	Glaciar	<i>Albizia chinensis, Betula alnoides, Buxus wallichiana, Rhododendron arboreum, Machilus odoratissima</i>
	Kapkot	<i>Bauhinia purpurea, Cinnamomum tamala, Machilus gamblei</i>
East Tarai Forest Division	Killapur	<i>Azadirachta indica, Bombax ceiba,</i>
	Kishanpur	<i>Bauhinia malabarica, Bauhinia racemosa, Sterculia villosa, Mitragyna parvifolia, Kydia calycina</i>
	Dolly	<i>Bauhinia racemosa, Schleicheria oleosa, Holoptelia integrifolia</i>
	Surai	<i>Bridelia retusa, Buchanania lanzan, Ficus microcarpam, Cordia dichotoma, Careya arborea, Syzygium nervosum, Cassia fistula, Salix tetrasperma, Miliusa tomentosa, Kydia</i>

		<i>calycina, Litsaea glutinosa, Madhuca longifolia</i>
	Khatima	<i>Carallia brachiata, Schleicheria oleosa, Flacourtia jangomas, Lagerstroemia parviflora</i>
	Lalkoti Sarda Poshak Nagar	<i>Bombax ceiba</i>
Valley of Flowers National Park		<i>Corylus jacquemontii, Betula utilis</i>
Dehradun Forest Division	Badkot	<i>Carallia brachiata, Acronechia pedunculata</i>
	Thano range	<i>Cordia dichotoma</i>
Haridwar Forest Division	Shyampur	<i>Adina cordifolia, Dalbergia lanceolaria, Butea monosperma, Acacia nilotica subsp. indica</i>
	Chidiyapur	<i>Alangium salviifolium, Aegle marmelos</i>
Narendra Nagar Forest Division	Devprayag	<i>Acacia catechu, Spondias pinnata</i>
Govind Pashu Vihar Division	Rupin	<i>Albizia julibrissin, Hovenia dulcis</i>
Tehri Forest Divison	Saklana	<i>Anogeissus latifolia, Bischofia javanica, Moringa pterygosperma, Olea paniculata</i>
	Paukhal	<i>Cassine glauca, Acacia catechu, Cassia fistula</i>
	Bhilangana	<i>Bahunia variegata, Sterculia villosa</i>
Mussoorie Forest Division	Raipur	<i>Boehmeria rugulosa, Bauhinia racemosa, Sophora mollis, Cassine glauca, Butea monosperma, Bridelia retusa, Bahunia semla, Oroxylum indicum</i>
	Jaunpur	<i>Berberis chitria</i>
	Kempty	<i>Sterculia villosa, Olea cuspidata</i>
Kalsi Soil Conservation Division	Timali	<i>Buchanania lanzan, Syzygium nervosum</i>
Rudraprayag Forest Division	Agastaumunia	<i>Cinnamomum tamala, Bahunia variegata</i>
	Jakholi	<i>Skimmia anquitalia, Rhododendron arboreum, Picea smithiana</i>
	Kankhara	<i>Celtis australis, Aegle marmelos</i>
	Rudraprayag	<i>Sterculia villosa, Mitragyna parvifolia</i>
Upper Yamuna Forest Division	Nao gaon	<i>Garunga pinnata</i>
Tons Forest Division	Sandra	<i>Hovenia dulcis</i>

e) Discription of Species

During the period, taxonomic description of the 200 Nos of FGR species has been prepared. It includes local name, synonyms, distribution (global, country and Uttarakhand), taxonomic description and live images of the species.

GERMPLASM COLLECTION

Table 11: List of species collected:

S.No.	Botanical Name	Family	Locality
1.	<i>Corylus jacquemontii</i>	Betulaceae	Uttarkashi
2.	<i>Prinsepia utilis</i>	Rosaceae	Chakrata
3.	<i>Skimmia anquitalia</i>	Rutaceae	Uttarkashi
4.	<i>Pistacia integerrima</i>	Meliaceae	Mussoorie
5.	<i>Pittosporum eriocarpum</i>	Pittosporaceae	Mussoorie
6.	<i>Trachycarpus takil</i>	Arecaceae	Munsiyari
7.	<i>Myrica esculenta</i>	Myricaceae	Khirsu
8.	<i>Cinnamomum tamala</i>	Lauraceae	Khirsu
9.	<i>Fraxinus micrantha</i>	Oleaceae	Khirsu

10.	<i>Careya arborea</i>	Lecythidaceae	Rajaji National Park
11.	<i>Milusa velutina</i>	Annonaceae	Rajaji National Park
12.	<i>Litsea glutinosa</i>	Lauraceae	Rajaji National Park
13.	<i>Carallia brachiata</i>	Rhizophoraceae	Rajaji National Park
14.	<i>Lannea coromandelica</i>	Anacardiaceae	Dehradun
15.	<i>Boehmeria rugulosa</i>	Urticaceae	Champawat
16.	<i>Mahonia jaunsarensis</i>	Berberidaceae	Chakrata
17.	<i>Catamixis bacharoides</i>	Asteraceae	Vyasi
18.	<i>Juglans regia</i>	Juglandaceae	Chirbitiya, Rudraprayag
19.	<i>Rhododendron arboreum</i>	Ericaceae	Chirbitiya, Rudraprayag
20.	<i>Cedrus deodara</i>	Pinaceae	Chirbitiya, Rudraprayag
21.	<i>Abies pindrow</i>	Pinaceae	Chopta, Rudraprayag

f) Preparation of Eco-distribution maps:

A total of 52 FGR species were shortlisted for the development of eco-distribution maps through wide consultations with the taxonomist and other experts of this field. Eco-distribution mapping of species is carried presently with latest geo-spatial modelling tools Arc GIS and ERDAS Imagine software, besides using Maxent species distribution model. LANDSAT-8 Satellite image of Uttarakhand was prepared for mapping.

A huge set of geo-spatial data are recorded on the basis of species occurrence in particular geographical area and also data on associated species was collected. At present, 70% of the updated data of species geo-spatial information (Longitude, Latitude, Slope, Aspect & Altitude) is completed. Maps for species such as *Bombax ceiba*, *Myrica esculenta*, *Diploknema butyracea*, *Quercus semecarpifolia*, *Quercus lanuginosa*, *Rhododendron arboreum*, *Tsuga dumosa*, *Quercus Glauca*, *Ougeinia oojeinensis* and *Juglans regia* are completed. In rest of the species, map construction and database upgradation is going on with the help of ground truthing. About 60% data of species associated with mapping species are updated. Range and Division wise species occurrence data is updated till December 2020.

Table 12: Current Status of eco-distribution mapping of FGR species

Sl. No.	Botanical Name	Family	Current Status
1.	<i>Bombax ceiba</i>	<i>Malvaceae</i>	Mapping completed
2.	<i>Myrica esculenta</i>	<i>Myricaceae</i>	
3.	<i>Diploknema butyracea</i>	<i>Sapotaceae</i>	
4.	<i>Quercus semecarpifolia</i>	<i>Fagaceae</i>	
5.	<i>Quercus lanuginosa</i>	<i>Fagaceae</i>	
6.	<i>Rhododendron arboreum</i>	<i>Ericaceae</i>	
7.	<i>Tsuga dumosa</i>	<i>Coniferae</i>	
8.	<i>Quercus glauca</i>	<i>Fagaceae</i>	
9.	<i>Ougeinia oojeinensis</i>	<i>Pipilionaceae</i>	
10.	<i>Juglans regia</i>	<i>Juglandaceae</i>	
11.	<i>Betula utilis</i>	<i>Cupuliferae</i>	
12.	<i>Oroxylum indicum</i>	<i>Bignoniaceae</i>	

13.	<i>Taxus baccata</i>	<i>Coniferae</i>	
14.	<i>Terminalia chebula</i>	<i>Combretaceae</i>	
15.	<i>Cinnamomum tamala</i>	<i>Lauraceae</i>	
16.	<i>Hymenodictyon orixense</i>	<i>Rubiaceae</i>	
17.	<i>Acer ceasium</i>	<i>Sapindaceae</i>	
18.	<i>Carpinus viminea</i>	Coryleae	
19.	<i>Fraxinus micrantha</i>	-----	
20.	<i>Populus ciliata</i>	<i>Salicaceae</i>	
21.	<i>Abies spectabilis</i>	<i>Coniferae</i>	
22.	<i>Buxus wallichiana</i>	Euphorbiaceae	
23.	<i>Bauhinia semla</i>	<i>Caesalpinaceae</i>	80-90 %
24.	<i>Cornus capitata</i>	Cornaceae	
25.	<i>Ficus neriifolia</i> var. <i>nemoralis</i>	Moraceae	
26.	<i>Pterospermum acerifolium</i>	Sterculiaceae	
27.	<i>Semecarpus anacardium</i>		
28.	<i>Stereospermum chelonoides</i>	Bignoniaceae	
29.	<i>Albizia odoratissima</i>	Mimocaceae	
30.	<i>Alnus nitida</i>	Cupuliferae	
31.	<i>Boswellia serrata</i>	Burseraceae	
32.	<i>Buchanania lanzan</i>	Anacardiaceae	
33.	<i>Buxus wallichiana</i>	Euphorbiaceae	60-80 %
34.	<i>Cassine glauca</i>	Celastraceae	
35.	<i>Corylus Jacquemontii</i>	Betulaceae	
36.	<i>Dispyros montana</i>	-----	
37.	<i>Juniperus macropoda</i>	Coniferae	
38.	<i>Pterocarpus marsupium</i>	-----	
39.	<i>Machilus gamblei</i>	-----	
40.	<i>Olea cuspidata</i>	Oleaceae	
41.	<i>Pittosporum napaulense</i>	Pittosporaceae	
42.	<i>Premna latifolia</i>	Verbenaceae	
43.	<i>Prunus cerasoides</i>	Rosaceae	
44.	<i>Trema orientalis</i>	Urticaceae	
45.	<i>Ulmus wallichiana</i>	Urticaceae	
46.	<i>Albizia julibrissin</i>	-----	
47.	<i>Carallia brachiata</i>	Rhizophoraceae	
48.	<i>Hovenia dulcis</i>	Rhamnaceae	
49.	<i>Litsaea glutinosa</i>	Lauraceae	
50.	<i>Madhuca longifolia</i>	Sapotaceae	

Table 13: GPS points of the following species were recorded during this quarter for the development of eco distribution maps

S.No	Botanical Name	GPS Points	S.No	Botanical Name	GPS Points
1	<i>Abies spectabilis</i>	2	22	<i>Myrica esculenta</i>	36
2	<i>Acer caesium</i>	6	23	<i>Olea cuspidata</i>	2
3	<i>Albizza julibrissin</i>	4	24	<i>Oroxylum indicum</i>	5
4	<i>Bauhinia semla</i>	16	25	<i>Ougeinia oojeinensis</i>	11
5	<i>Bombax ceiba</i>	21	26	<i>Pittosporum napaulense</i>	1
6	<i>Boswellia serrata</i>	3	27	<i>Populus ciliata</i>	4
7	<i>Buchanania lanzan</i>	3	28	<i>Premna latifolia</i>	11
8	<i>Buxus wallichiana</i>	1	29	<i>Prunus cerasoides</i>	11
9	<i>Carallia brachiata</i>	1	30	<i>Pterospermum acerifolium</i>	2
10	<i>Carpinus viminea</i>	4	31	<i>Quercus glauca</i>	2
11	<i>Cassine glauca</i>	7	32	<i>Quercus lanata</i>	7
12	<i>Cinnamomum tamala</i>	7	33	<i>Semecarpus anacardium</i>	7
13	<i>Cochlospermum religiosum</i>	2	34	<i>Stereospermum chelonoides</i>	8
14	<i>Cornus capitata</i>	2	35	<i>Taxus baccata</i>	2
15	<i>Diploknema butyracea</i>	1	36	<i>Terminalia chebula</i>	4
16	<i>Ficus nerifolia</i> var. <i>nemoralis</i>	12	37	<i>Trema orientalis</i>	9
17	<i>Flacourtia jangomas</i>	5			
18	<i>Fraxinus micrantha</i>	1			
19	<i>Hymenodictyon orixense</i>	5			
20	<i>Juglans regia</i>	4			
21	<i>Madhuca longifolia</i>	7			

B. FGR SEED AND GERMPLASM STORAGE

1. Collaboration with NBPGR, New Delhi

A Memorandum of Agreement (MoA) between National Bureau of Plant Genetic Resources (NBPGR) and FRI was signed regarding use of plant germplasm conservation facilities i.e. Seed bank facilities by FRI for long-term conservation of seed germplasm of prioritised forestry species. The MoA was signed by the Directors of the two institutes on 22-08-2017. This MoA facilitates the transfer of processed seed germplasm of FGR species as per the Seed bank norms to the Seed bank of NBPGR for long-term conservation at -18⁰C.

2. Survey of populations for seed collection

It is intended to collect seeds of 90 important FGR species in this project for their storage and conservation. Surveys were conducted for demarcation of populations of important FGR species and availability of their seeds.

Table 14: List of species surveyed for seed collection

Forest Range	Species surveyed
Agrakhal, Narendra Nagar Forest Division	<i>Kydia calycina</i>
Almora FD	<i>Celtis tetrandra</i>
Almora Forest Range, Almora Forest Division	<i>Myrica esculenta, Quercus leucotrichophora, Toona ciliata</i>
Barakoli Forest Range, Sitarganj, East Tarai Forest Division, Haldwani	<i>Acacia catechu, Dalbergia sisoo, Holoptelia integrifolia, Schleicheria oleosa, Tinospora cordifolia</i>
Barhani Forest Range, Central Tarai Forest Division, Haldwani	<i>Acacia catechu, Aegle marmelos, Bombax ceiba, Holoptelia integrifolia, Mallotus philippensis,</i>
Bhakhra Forest Range, Central Tarai Forest Division, Haldwani	<i>Aegle marmelos, Emblica officinalis</i>
Bhararisain, Gairsain forest areas	<i>Rhododendron arboretum</i>
Binsar Wildlife sanctuary	<i>Rhododendron arboreum</i>
Buranskhanda, Mussoorie FD	<i>Buxus wallichiana</i>
Buranskhanda, Dhanaulti	<i>Fraxinus micrantha</i>
Buranskhanda, Dhaunaulti	<i>Fraxinus micrantha</i>
Chamba Koti colony, Tehri Forest Division	<i>Zizyphus jujuba</i>
Chhakata Range, East Tarai Forest Division, Haldwani	<i>Acacia catechu, Adina cordifolia, Holoptelia integrifolia,</i>
Chhilderwala, Near Kansrao range	<i>Oroxylum indicum</i>
Deoghar Range, Tuini Forest Division	<i>Rhus parviflora, Berberis lyceum, Zizyphus oxyphylla</i>
Deovan, Chakrata	<i>Abies spectabilis, Taxus baccata, Berberis lyceum</i>
Dugra Forest, Bhatwara, Tehri Forest Division	<i>Bauhinia retusa</i>
Dr.Sushila Tiwari Herbal Garden, Rishikesh	<i>Dalbergia lanceolaria</i>
Dyuda Forest, Bhatwara Tehri Forest Division	<i>Adhatoda vasica</i>
Fatehpur Forest Range, Ramnagar Forest Division	<i>Adina cordifolia, Aegle marmelos, Anogeissus latifolia, Bombax ceiba, Dalbergia sisoo, Holoptelia integrifolia, Desmodium oojeinensis, Schleicheria oleosa, Terminalia bellerica, Toona ciliata</i>
FRI Campus, Dehradun	<i>Koelreuteria paniculata, Terminalia chebula, Terminalia citrina</i>
Garhi Cantt, Dehradun Forest Division	<i>Albizia lucidior</i>
Gaula Forest Range, Haldwani Forest Division	<i>Albizia odoratissima, Acacia catechu</i>
Ghanderdhar Forest, Bhatwara, Tehri Forest	<i>Cassine glauca</i>

Division	
Haldwani Forest Range, Central Tarai Forest Division, Haldwani	<i>Adina cordifolia, Albizzia procera</i>
Haridwar Forest Area	<i>Alangium salviifolium, Dalbergia lanceolaria</i>
Jampokhra, Chakata Range, Haldwani	<i>Bauhinia malabarica</i>
Jamunchata, Kansro Rajaji TR	<i>Gmelina arborea</i>
Jaunpur range, Mussoorie Forest Division	<i>Buxus wallichiana</i>
Jharipani near Mussoorie	<i>Pittosporum floribundum, Pittosporum nepalense, Cryptolepis buchananii, Rhamnus triquetra</i>
Jhilmil Rest House, Haridwar Forest Division	<i>Stereospermum chelonoides</i>
Jhingardhar Forest, Bhatwara, Tehri Forest Division	<i>Cryptolepis buchananii</i>
Jumma, Jhelam Van Panchayat, Joshimath Range	<i>Hippophae salicifolia</i>
Kaladhoongi Forest Range, Ramnagar Forest Division	<i>Adina cordifolia, Anogeissus latifolia, Lannea grandis, Schleicheria oleosa</i>
Kanasar Range, Chakrata (Deovan) Forest Division	<i>Taxus baccata, Berberis chitria, Abies pindrow, Picea smithiana, Acer caesium</i>
Kanchulakhark, Mandal Forest	<i>Corylus colurna</i>
Kansro Forest Range, Dehradun Forest Division	<i>Adina cordifolia, Aegle marmelos, Albizzia procera, Holoptelia integrifolia, Lannea grandis, Schleicheria oleosa, Terminalia bellerica</i>
Kansro range, Motichur	<i>Schleicheria oleosa</i>
Kansro Range, Motichur, Rajaji NP	<i>Schleicheria oleosa</i>
Kansro, Rajaji TR	<i>Buchanania lanzan, Albizia odoratissima</i>
Khankra, Rudraprayag	<i>Oroxylum indicum</i>
Khirsu, Civil Soyam, Garhwal Forest Division	<i>Alnus nepalensis</i>
Kilbari, Nainital Forest	<i>Carpinus viminea</i>
Kilmori Forest, Bhatwara, Tehri Forest Division	<i>Bauhinia vahlii</i>
Kishanpur Forest Range, Haldwani Forest Division	<i>Bombax ceiba, Lagerstroemia parviflora</i>
Kosi, Almora FD	<i>Pyrus pashia</i>
Koyalpura, Kansro, Rajaji NP	<i>Careya arborea</i>
Koyalpura, Kansro, Rajaji TR	<i>Careya arborea</i>
Lachhiwala Range	<i>Acacia catechu, Dalbergia sisoo</i>
Maangu Forest, Bhatwara, Tehri Forest Division	<i>Flacourtia indica</i>
Mandapur, Raipur Range	<i>Cinnamomum tamala</i>
Mansa devi temple, Haridwar FD	<i>Dalbergia lanceolaria, Boswellia serrata,</i>
Mansa Devi Temple, Rajaji NP	<i>Albizia odoratissima</i>
Mayawati, Lohaghat Forest	<i>Carpinus viminea, Cedrus deodara</i>
Mothrowala swamp, Dehradun	<i>Carallia brachiata, Ficus glaberrima</i>
Motichur F. Rest House	<i>Celtis tetrandra</i>
Mussoorie Forest Division	<i>Coxxulus laurifolius</i>
Nandhaur Forest Range, East Tarai Forest Division, Haldwani	<i>Acacia catechu, Adina cordifolia, Dalbergia sisoo, Dioscorea bulbifera, Desmodium oojeinensis, Schleicheria oleosa,</i>
Narendra nagar Forest Division	<i>Hymenodictyon excelsum, Spondias pinnata</i>
Narendra Nagar, Tehri FD	<i>Cassine glauca</i>
Near Chandi Devi temple route, Haridwar	<i>Dalbergia lanceolaria</i>
Near Chandi devi, Haridwar FD	<i>Cochlospermum religiosum</i>
Near Dwarahat, Almora	<i>Engelhardtia spicata</i>
Near Julikot, Nainital forest areas	<i>Leucomeris spectabilis</i>
Pashimi beat, Jamun Khata, Motichur TR	<i>Diospyros exculeata</i>
Pipalpadav Forest Range, Central Tarai Forest Division, Haldwani	<i>Acacia catechu, Bombax ceiba</i>
Raiwala road, Haridwar Forest Division	<i>Albizia procera</i>
Rajaji Tiger Reserve, Motichur	<i>Ougenia oojeinensis, Toona ciliate, Bombax ceiba, Terminalia chebula, Terminalia bellerica,</i>

	<i>Schleichera oleosa</i>
Ramgarh Park Range/Forest Range	<i>Terminalia chebula, Ougenia oojeinensis, Aegle marmelos, Syzygium cuminii, Toona ciliata</i>
Ramgarh Range, Almora	<i>Rhododendron arboreum</i>
Ramnagar, Nainital Forest Division	<i>Streblus asper</i>
Ranikhet FD, Gairsain	<i>Bombax ceiba</i>
Ranikhet Forest Range, Almora Forest Division	<i>Myrica esculenta, Quercus leucotrichophora,</i>
Rishikesh Forest Range, Dehradun Forest Division	<i>Aegle marmelos, Albizzia procera, Bombax ceiba, Holoptelia integrifolia,</i>
Sahiya, Chakrata Forest Division	<i>Albizzia chinensis</i>
Sanjha Darbar, Mussoorie Forest Range	<i>Lyonia oyalifolia</i>
Shyampur Forest Range, Haridwar	<i>Alangium salvifolium</i>
Soni, Ranikhet Range	<i>Punica granatum</i>
Tanda Forest Range, Central Tarai Forest Division, Haldwani	<i>Acacia catechu, Garuga pinnata, Mallotus philippensis, Toona ciliata</i>
Teenpani, Chidderwala Rajaji NP	<i>Acronychia pedunculata</i>
Thalka Forest, Bhatwara, Tehri Forest Division	<i>Indigofera cassioides</i>
Thapli Forest, Bhatwara, Tehri Forest Division	<i>Dodonea viscosa</i>
Tilwadi, Bhauwala, Jhajhra Range, Dehradun Forest Division	<i>Pterospermum acerifolium</i>
Timli Forest Range	<i>Syzygium cuminii, Terminalia bellerica, Holoptelia integrifolia, Dalbergia sisoo, Albizzia procera (kalasirus), Diospyros Montana, Sterculia villosa, Litsea glutinosa</i>
Vinayak Chatti, Badrinath Forest Division	<i>Toona serrata</i>
Yamuna pul, Mussoorie Forest Division	<i>Kydia calycina</i>

3. Collection of seeds of FGRs

Seeds of the prioritized FGR species were collected from their natural distribution areas through appropriate collection methods.

Table 15: Site of seed collection for different species

Species	Site of seed collection
<i>Acacia catechu</i>	Thano range
	Near Juddo toward Kalsi Forest Areas
<i>Acer caesium</i>	Kanasar Range, Chakrata (Deovan) Forest Division
<i>Acer oblongum</i>	FRI Campus, Dehradun
<i>Acrocarpus fraxinifolius</i>	FRI Campus, Dehradun
<i>Acronychia pedunculata</i>	Teenpani, Lal Tappad, Rajaji National Park
<i>Adhatoda vasica</i>	Dyuda Forest, Bhatwara, Tehri Forest Division
<i>Adenanthera microsperma</i>	FRI Campus, Dehradun
<i>Aegle marmelos</i>	Kansro Forest Range, Dehradun Forest Division, Fatehpur Forest Range, Ramnagar Forest Division,
	Dolpokhra beat, Chakata Range, Haldwani
	Kirtinagar, Srinagar Forest areas
<i>Ailanthus excelsa</i>	Sirsoli, Ukhimath, Kedarnath Forest Division
<i>Alangium salvifolium</i>	Haldwani Forest Division
<i>Albizzia chinensis</i>	Sahiya, Chakrata Forest Division
<i>Albizzia julibrissin</i>	Arakot, Chamba
<i>Albizzia lucidior</i>	Garhi Cantt, Dehradun Forest Division
<i>Albizzia odoratissima</i>	Rajpur, Mussoorie forest area
<i>Alnus nepalensis</i>	Kiskot Village, Champawat Range

	Bhetsem, Guptkashi Kedarnath Forest Division
	Khirsu, Civil Soyam, Garhwal Forest Division
<i>Albizia procera</i>	Raiwala road, Haridwar Forest Division
<i>Aristolochia elegans</i>	Jauljivi, Pithoragarh FD
<i>Bauhinia retusa</i>	Dugra Forest, Bhatwara, Tehri Forest Division
<i>Bauhinia vahlii</i>	Kilmori Forest, Bhatwara, Tehri Forest Division
<i>Bauhinia variegata</i>	FRI Campus, Dehradun
<i>Berberis vulgaris</i>	Kedar Valley, Kedarnath Forest Division
<i>Berberis lycium</i>	Deoghar Range, Tuini Forest Division
<i>Betula utilis</i>	Mana, Badrinath Forest Division
<i>Bischofia javanica</i>	Jauljivi, Pithoragarh FD
<i>Buchanania lanzan</i>	Near Chandidevi Temple
<i>Buxus wallichiana</i>	Near Jadi, Chakrata Forest Division
	Kedarnath WLS Mandal Forest
	Jadi, Chakrata Forest Division
<i>Callistemon viminalis</i>	FRI Campus, Dehradun
<i>Careya arborea</i>	Koyalpura, Kansro, Rajaji NP
	Motichur range, Rajaji TR
<i>Carpinus viminea</i>	Chopta-Mandal Forest, Kedarnath WLS, Mandal Kilbari, Nainital Forest
	Kanchula Khark, Mandal, Kedarnath Forest Division
<i>Cassine glauca</i>	Ghanderdhar Forest, Bhatwara, Tehri Forest Div
<i>Cassia glauca</i>	FRI Campus, Dehradun
<i>Cassia javanica</i>	FRI Campus, Dehradun
<i>Cedrus deodara</i>	Patal-Bhuwneswar, Gangolihaat Mayawati, Lohaghat Forest
<i>Celastrus paniculatus</i>	Narkota, Rudraprayag Forest Division
<i>Celtis australis</i>	Chaprali, Pauri Forest Division
<i>Celtis tetrandra</i>	Almora Forest Division
<i>Chukrasiatubularis</i>	FRI Campus, Dehradun
<i>Cinnamomum tamala</i>	Bhaunkhal
<i>Cinnamomum camphora</i>	FRI Campus, Dehradun
<i>Coxxulus laurifolius</i>	Mussoorie Forest Division
<i>Cordia dichotoma</i>	Judo, Kalsi Forest Division, Dehradun
<i>Corylus colurna</i>	Mandal Forest, Kedarnath Wildlife Sanctuary
<i>Cryptolepis buchananii</i>	Jhingardhar, Bhatwara, Tehri Forest Division
<i>Cupressus torulosa</i>	FRI Campus, Dehradun
<i>Dalbergia sissoo</i>	Near Haripur, Kalsi forest areas Thano range
<i>Dalbergia lanceolaria</i>	Dr.Sushila Tiwari Herbal Garden, Rishikesh
<i>Delonix regia</i>	FRI Campus, Dehradun
<i>Desmodium oojainensis</i>	Rajaji Tiger Reserve, Dehradun Forest Division Almora forest areas
<i>Diospyros montana</i>	Sahia, Kalsi Range Timli Forest Division
<i>Diospyros tomentosa/ exsculpta</i>	Near Ramnagar

<i>Dipterus assamica</i>	Nakraunda
<i>Dodonea viscosa</i>	Thapli Forest, Bhatwara, Tehri Forest Division
<i>Engelhardtia spicata</i>	Dugadda, Raipur
	Near Chimtakhall to Bhawankhal
<i>Enterolobium contortisiliquum</i>	FRI Campus, Dehradun
<i>Flacourtia indica</i>	Maangu Forest, Bhatwara, Tehri Forest Division
<i>Fraxinus xanthoxyloides</i>	Kailashpur, Malari Beat, Joshimath Range
	Niti, Badrinath, Forest Division
<i>Fraxinus micrantha</i>	Buranskhanda, Dhanaulti
	Near Forest Rest House, Kedarnath WLS, Mandal
<i>Gmelina arborea</i>	Sushila Tiwari Herbal Garden, Rishikesh
	Muni kiReti, Rishikesh
<i>Grewia optiva</i>	Chaprali, Pauri Forest Division
<i>Hippophae salicifolia</i>	Jumma, Jhelam Van Panchayat Joshimath Range
<i>Holoptelia integrifolia</i>	Kansro Forest Range, Dehradun Forest Division,
	Timli Forest Range, Dehradun Forest Division
<i>Hymenodictyon excelsum</i>	Ramnagar
<i>Ilex dipyrena</i>	Deoban, Kanasar Range, Chakrata Forest Division
<i>Indigofera cassioides</i>	Thalka Forest, Bhatwara, Tehri Forest Division
<i>Jacaranda mimosifolia</i>	FRI Campus, Dehradun
<i>Juglans regia</i>	Vinayak, Kosi Range Nainital Forest Division
<i>Kydia calycina</i>	Near Yamuna Pul toward Kempty fall, Mussoorie Forest
	Agrakhal, Narendra Nagar Forest Division
	Yamuna pul, Mussoorie Forest Division
<i>Koelreuteria paniculata</i>	FRI Campus, Dehradun
<i>Leucomeris spectabilis</i>	Kaddukhal, Mussoorie FD
	Near Chimtakhall to Bhawankhal
<i>Lyonia ovalifolia</i>	Kedar Valley, Kedarnath Forest Division
	Sanjha Darbar, Kempty Fall, Mussoorie Forest Division
<i>Melia composita</i>	FRI Campus, Dehradun
<i>Myrica esculenta</i>	Near Bhatronj Khan, Rannagar-Karnprayag Highway
<i>Neolamarckia cadamba</i>	FRI Campus, Dehradun
<i>Oroxylum indicum</i>	Motichoor Range, Rajaji National Park
	Near Chhiddarwala, Near Kansrao range
	KhankraRudraPrayag, Forest area
	Jwalasal Range, East Tarai
<i>Ougenia oojeinensis</i>	Rajaji Tiger Reserve, Dehradun Forest Division
<i>Picea smithiana</i>	Kanasar Range, Chakrata (Deovan) Forest Division
<i>Pinus wallichiana</i>	Tanta Village, Dharchula Range
	Near Gamshali, Joshimath Range
<i>Pittosporum napaulense</i>	The Doon School, Dehradun
<i>Premna latifolia</i>	Raipur, Dehradun Forest Division
<i>Punica granatum</i>	Soni, Ranikhet Range
<i>Putranjiva roxburghii</i>	FRI Campus, Dehradun
<i>Pyrus pashia</i>	Narayanswami, Pithoragarh Range
	Champawat Range
<i>Pyracantha crenulata</i>	Korwa, Chakrata Forest Division

<i>Rhamnus triquetra</i>	Jhadipani, Mussoorie Forest Division
<i>Rhus parviflora</i>	Deoghar Range, Tuini Forest Division
<i>Rhus punjabensis</i>	Kantha, Ukhimath, Kedarnath Forest Division
<i>Rubus ellipticus</i>	Purola, Tons Forest Division
<i>Schleichera oleosa</i>	Chilla Range, Gohri Range, Kalsi, Narendra Nagar, Rajaji National Park
	Chilla, Rajaji NP
	Juddo, Kalsi FD
	Gohari Range
<i>Spondias pinnata</i>	Sahia, Kalsi Range
<i>Taxus baccata</i>	Kanasar Range, Chakrata (Deovan) Forest Division
<i>Terminalia bellerica</i>	Kansro Forest Range, Dehradun Forest Division,
<i>Terminalia chebula</i>	FRI Campus, Dehradun
<i>Terminalia citrina</i>	FRI Campus, Dehradun
<i>Toona ciliata</i>	Rajaji Tiger Reserve, Dehradun Forest Division,
	Almora Forest Range, Almora Forest Division
	Ranibagh, Haldwani
<i>Toona serrata</i>	Sanjha Darbar, Kempty Fall Mussoorie Forest Division
<i>Ulmus wallichiana</i>	Near Jadi Village Chakrata
<i>Zizyphus jujuba</i>	Chamba koti colony, Tehri Forest Division
<i>Zizyphus oxyphylla</i>	Deoghar Range, Tuini Forest Division

4. Seed extraction and processing

Seeds were extracted from the ripened fruits of all the species, cleaned and processed for further tests. Initial parameters on seed weight, seed dimensions, seed moisture content, seed germination, etc. were recorded.

5. Seed Drying and Storage

Seeds were kept in storage at ambient room temperature for after-ripening, desiccated to lower moisture levels with silica gel and stored under low temperature (5°C) in Low Temperature Storage Cabinet. Seeds were dried in cool air dryer at 15°C and 15% relative humidity for slow desiccation to safe moisture levels for storage.

Table 16: Germination percentage and moisture content of stored seeds

Species	Moisture (%)	Germination (%)
<i>Acacia catechu</i> (Thano)	12.96	85
<i>Acacia catechu</i> , Near Dakpaththar, Kalsi	12.1	Under progress
<i>Acacia catechu</i> , Near Juddo, Kalsi Forest	12.25	81
<i>Acer caesium</i>	18.75	Under process
<i>Acer oblongum</i> , FRI Campus, Dehradun	13.2	
<i>Acrocarpus fraxinifolius</i> , FRI Campus, Dehradun	6	
<i>Acronychia pedunculata</i>	-	Under process
<i>Adhatoda vasica</i> , Dyuda Forest, Bhatwara Tehri Forest Division	9.96	
<i>Aegle marmelos</i> (Haldwani)	4.77	100
<i>Aegle marmelos</i> (Kansro)	5.14	64
<i>Aegle marmelos</i> (Sri Nagar)	6.09	84
<i>Aegle marmelos</i> , Srinagar Forest areas	6.09	94
<i>Aegle marmelos</i> , Chakrata, Haldwani	4.76	98
<i>Ailanthus excelsa</i>	12.47	48

<i>Alangium salviifolium</i>	48.88	97
<i>Albizia chinensis</i> , Sahiya, Chakrata Forest Division	12.37	73
<i>Albizia lucidior</i> , Garhi Cantt, Dehradun Forest Division	12.97	90
<i>Albizia odoratissima</i> , Mussoorie forest	8.7	Under process
<i>Albizia procera</i> , Raiwala road, Haridwar Forest Division	13.27	53
<i>Albizia julibrissin</i>	9.86	14
<i>Alnus nepalensis</i>	10.71	Under process
<i>Alnus nepalensis</i> , Khirsu, Civil Soyam, Garhwal Forest Division	4.54	45 germinants/0.02gms seeds
<i>Bauhinia retusa</i> , Dugra Forest, Bhatwara, Tehri Forest Division	12.85	
<i>Bauhinia vahlii</i> , Kilmori Forest, Bhatwara, Tehri Forest Division	14.58	
<i>Bauhinia variegata</i> , FRI Campus, Dehradun	6	
<i>Berberis aristata</i>	6	78
<i>Berberis lycium</i>	7.17	83
<i>Berberis vulgaris</i>	23.91	65
<i>Betula utilis</i>	12.5	Under process
<i>Buchanania lanzan</i>	7.27	68
<i>Buchanania lanzan</i>	7.27	Under progress
<i>Buxus wallichiana</i>	11.42	under progress
<i>Buxus wallichiana</i> , Chakrata forest	11.42	Under process
<i>Buxus wallichiana</i> , Mandal forest	10.61	
<i>Buxus wallichiana</i> , Jadi, Chakrata Forest Division	11.29	48
<i>Callistemon viminalis</i> , FRI Campus, Dehradun	8.1	
<i>Careya arborea</i>	32.53	100
<i>Carpinus viminea</i> , Kilbari, Nainital Forest	14.29	Under process
<i>Carpinus viminea</i> , Mandal forest	12.75	Under process
<i>Carpinus viminea</i> , Kanchula Khark, Mandal Kedarnath Forest Division	12.25	23
<i>Cassine glauca</i> , Ghanderdhar Forest, Bhatwara, Tehri Forest Division	19.72	
<i>Cedrus deodara</i> , Mayawati, Lohaghat Forest	21.69	62
<i>Celastrus paniculatus</i>	9.98	Under process
<i>Celtis australis</i>	5.83	Under process
<i>Celtis tetrandra</i>	5.26	21
<i>Celtis tetrandra</i> , Almora Forest Division	5.26	63
<i>Chukrasia tabularis</i> , FRI Campus Dehradun	9.22	
<i>Cinnamomum tamala</i>	4.88	Under process
<i>Cocculus laurifolius</i> , Mussoorie Forest Division	16.3	90
<i>Cordia dichotoma</i> , Judo, Kalsi Forest Division, Dehradun	15.8	
<i>Corylus colurna</i> , Mandal Forest, Kedarnath Wildlife sanctuary	10.99	74
<i>Cryptolepis buchananii</i> , Jhingardhar, Bhatwara, Tehri Forest Division	15	
<i>Cupressus torulosa</i> , FRI Campus, Dehradun	10.37	
<i>Dalbergia lanceolaria</i>		Nil (fungal infestation)
<i>Dalbergia lanceolaria</i> , Dr.Sushila Tiwari Herbal Garden, Rishikesh	13.38	86
<i>Dalbergia sissoo</i> (Thano)	6.09	100
<i>Dalbergia sissoo</i> (Upper Yamuna)	6.09	95
<i>Dalbergia sissoo</i> , Kalsi Range	10.5	92
<i>Delonix regia</i> , FRI Campus, Dehradun	10	

<i>Desmodium oojeinensis</i>	8.79	100
<i>Diospyros montana</i>	13.09	65
<i>Diospyros montana</i>	17.6	36
<i>Diospyros Montana</i> , Timli Forest Division	26.55	31
<i>Diospyros tomentosa</i>	21.7	Under progress
<i>Diospyros tomentosa/ exsculpta</i>	21.7	100 (Location 1)
		93.33 (Location 2)
<i>Dipterus assamica</i>	37.61	Under Process
<i>Dipterus assamica</i>	20	99
<i>Dodonea viscosa</i> , Thapli Forest, Bhatwara, Tehri Forest Division	14.58	
<i>Engelhardtia spicata</i>	11.02	Under Process
<i>Flacourtia indica</i> , Maangu Forest, Bhatwara, Tehri Forest Division	8.86	
<i>Fraxinus micrantha</i>	11.23	under progress
<i>Fraxinus micrantha</i>	6.07	73
<i>Fraxinus micrantha</i> , Dhanaulti	6	93
<i>Fraxinus micrantha</i> , Kedarnath	13.9	83
<i>Fraxinus xanthoxyloides</i> , Joshimath	11.93	Under process
<i>Fraxinus xanthoxyloides</i> , Niti, Badrinath Forest Division	12.41	Under process
<i>Grewia optiva</i>	19.93	54
<i>Gmelina arborea</i>	20.21	Under process
<i>Hippophae salicifolia</i> (Badrinath)	6	82
<i>Hippophae salicifolia</i> (Niti)	11.14	85
<i>Hippophae salicifolia</i> , Joshimath range	14.19	85
<i>Hymenodictyon excelsum</i>	5.29	87
<i>Hymenodictyon excelsum</i>	5.29	Under progress
<i>Ilex dipyrena</i> , Deoban, Chakrata Forest Division	15.36	Under process
<i>Indigofera cassioides</i> , Thalka Forest, Bhatwara, Tehri Forest Division	10	
<i>Jacaranda mimosifolia</i> , FRI Campus, Dehradun	5.44	
<i>Juglans regia</i>	5.87	19
<i>Juglans regia</i> , Vinayak, KosiRange, Nainital Forest Division	13.09	56
<i>Koelreuteria paniculata</i> , FRI campus, Dehradun	7.98	87
<i>Kydia calycina</i>	17	39
<i>Kydia calycina</i> , Agrakhal, Narendra Nagar Forest Division	13.2	48
<i>Kydia calycina</i> , Mussoorie Forest div.	10.84	Under progress
<i>Leucomeris spectabilis</i>	10.35	Under Process
<i>Lyonia ovalifolia</i> , Kedarnath Forest Division	10.65	Under process
<i>Lyonia ovalifolia</i> , Sanjha Darbar, Mussoorie Forest Division	6.81	68 germinants/0.01 gm seeds
<i>Melia composite</i> , FRI Campus, Dehradun	9.75	
<i>Myrica esculenta</i>	7	20
<i>Oroxylum indicum</i>	6.38	92
<i>Oroxylum indicum</i>	6.33	89
<i>Oroxylum indicum</i> (Mansa Devi)	8.45	97
<i>Oroxylum indicum</i> (Rudra prayag)	6	100
<i>Oroxylum indicum</i> , Rajaji NP	14.76	Under progress
<i>Picea smithiana</i>	15.14	Under process
<i>Pinus wallichiana</i> (Dhanaulti)	11.69	40
<i>Pinus wallichiana</i> (Niti)	6.7	14
<i>Pinus wallichiana</i> , Dhanaulti	11.69	68
<i>Pinus wallichiana</i> , Joshimath range	11.24	70
<i>Punica granatum</i> , Soni, Ranikhet Range	10.27	59

<i>Putranjiva roxburghii</i> , FRI Campus, Dehradun	5	
<i>Pyracantha crenulata</i>	17.47	66
<i>Rhamnus triquetra</i>	8.25	45
<i>Rhus parviflora</i>	24.77	51
<i>Rhus punjabensis</i> , Ukhimath, Kedarnath Forest Division	9.8	Under process
<i>Schleichera oleosa</i> (Chilla, Rajaji NP)	24.36	35(seeds were infested with fungus)
<i>Schleichera oleosa</i> (Gohari Range)	25.67	
<i>Schleichera oleosa</i> (Juddo, Kalsi FD)	27.16	
<i>Schleichera oleosa</i> (Rajaji NP)	16	66
<i>Taxus baccata</i>	12.39	Under process
<i>Terminalia chebula</i> , FRI campus, Dehradun	12.86	47
<i>Terminalia citrina</i> , FRI campus, Dehradun	10.67	74
<i>Toona ciliata</i>	5.96	94
<i>Toona serrata</i>	16.24	Under process
<i>Ulmus wallichiana</i>	11	Under Process
<i>Zizyphus jujuba</i>	10.95	Under process
<i>Zizyphus oxyphylla</i>	15.84	Under process

6. Quarterly Viability testing of seeds

Germination test were conducted on the stored seeds of different species.

Table 17: Viability of stored seeds

S.No	Species	Germination%
1	<i>Aegle marmelos</i> (Chakrata range)	93
2	<i>Aegle marmelos</i> (Rajaji)	55
3	<i>Aegle marmelos</i> (Motichur, Rajaji NP)	46
4	<i>Aegle marmelos</i> (Haldwani Forest Division)	76
5	<i>Aegle marmelos</i> (Kansro Range)	73
6	<i>Aegle marmelos</i> (Motichur)	58
7	<i>Aegle marmelos</i> (27 months)	96
8	<i>Acacia catechu</i>	58
9	<i>Acacia catechu</i> (Thano)	66
10	<i>Albizia chinensis</i>	70
11	<i>Albizia julibrissin</i>	58
12	<i>Albizia julibrissin</i> (Chamba, Tehri)	32
13	<i>Albizia procera</i>	20
14	<i>Alnus nepalensis</i> (Guptkashi)	7
15	<i>Aristolochia elegans</i>	7
16	<i>Aristolochia elegans</i> (Storage period 45 months)	10
17	<i>Aristolochia elegans</i>	49
18	<i>Aristolochia elegans</i> (Jauljivi, Pithoragarh)	9
19	<i>Berberis lycium</i>	80
20	<i>Betula utilis</i> (Mana)	27 germinants/0.02gm seeds
21	<i>Bischofia javanica</i>	71
22	<i>Celastrus paniculatus</i> (Narkota)	91
23	<i>Celtis australis</i> (Chaprali)	14
24	<i>Celtis tetrandra</i>	63

25	<i>Celtis tetrandra</i> (Almora)	3
26	<i>Crotolaria cytisoides</i> (Mussoorie)	91
27	<i>Corylus colurna</i> ,	74
28	<i>Dalbergia lanceolaria</i>	84
29	<i>Dalbergia sissoo</i>	95
30	<i>Dalbergia sissoo</i> (Dakpathar)	96
31	<i>Dalbergia sissoo</i> (Dakpathar)	96
32	<i>Dalbergia sissoo</i> (Dakpathar) 29 months	98
33	<i>Desmodium oojeinensis</i>	54
34	<i>Diospyros montana</i>	31
35	<i>Fraxinus micrantha</i> (Mandal)	75
36	<i>Fraxinus xanthoxyloides</i>	03
37	<i>Fraxinus xanthoxyloides</i> (Niti)	22 (Pre-treatment: 0.03% GA ₃ for 24 hours))
38	<i>Fraxinus micrantha</i> (Mandal 35 months)	90
39	<i>Fraxinus micrantha</i> (Dhanaulti)	95
40	<i>Hippophae salicifolia</i> (Upper Yamuna) 48 months	89
41	<i>Hippophae salicifolia</i> (Hanumanchatti)	95
42	<i>Hippophae salicifolia</i>	81
43	<i>Hippophae salicifolia</i> (Upper Yamuna)	99
44	<i>Holoptelea integrifolia</i>	79
45	<i>Juglans regia</i>	56
46	<i>Kydia calycina</i> (Yamuna Pul)	48
47	<i>Myrica esculenta</i>	24
48	<i>Myrica esculenta</i> (Chaukhutiya, Almora)	47 (Pre-treatment: Hot water soaking at 70 ⁰ C for 24 hours)
49	<i>Oroxylum indicum</i> (Rudraprayag)	100
50	<i>Oroxylum indicum</i> (Rudraprayag)	95
51	<i>Oroxylum indicum</i> (Motichur, 31 months)	89
52	<i>Pinus wallichiana</i>	39
53	<i>Pinus wallichiana</i> (Dhanaulti)	67
54	<i>Pinus wallichiana</i> (Dhanaulti) (36 months)	84
55	<i>Pinus wallichiana</i> (Dharchula)	97
56	<i>Picea smithiana</i>	67
57	<i>Pinus wallichiana</i> (Joshimath)	85
58	<i>Punica granatum</i>	59
59	<i>Pyrus parshia</i> (CH)	54
60	<i>Pyrus pashia</i> (Champawat) 45 months	83 (GA ₃ , 0.01%)
61	<i>Pyrus parshia</i> (Narayanswami)	34
62	<i>Rhamnus triquetra</i>	80
63	<i>Rhododendron arboreum</i>	9360 germinants/1 gm of seeds
64	<i>Rhododendron arboreum</i> (52 months)	418 seedlings/gm seed
65	<i>Rhus punjabensis</i> (Kantha)	6
66	<i>Schleichera oleosa</i>	52
67	<i>Terminalia bellerica</i>	68.5
68	<i>Toona ciliata</i> (Haldwani)	63
69	<i>Toona ciliata</i> (Rajaji NP) 52 months	5

70	<i>Toona ciliata</i> (Haldwani)	80
71	<i>Toona serrata</i> (Kempty Fall)	77
72	<i>Uncaria pilosa</i> (45 months)	379 seedlings/gm seed
73	<i>Uncaria pilosa</i> (Bageshwar, Almora)	3,240/g
74	<i>Uncaria scandens</i>	7920 germinants/1gm of seeds

7. Sample preparation of collected FGR species for the long term conservation at NBPGR, New Delhi:

The samples were processed and desiccated up to safe moisture level for long-term storage in Seed Genebank. The detail of the prepared samples is as below:

Table 18: List of samples prepared for long term storage in seed gene bank

S. No.	Species Name	Samples	Source
1	<i>Acacia catechu</i>	02	Thano Range, Dehradun
			Juddo, Kalsi FD
2	<i>Acer oblongum</i>	02	FRI Campus, Dehradun
3	<i>Acrocarpus fraxinifolius</i>	02	FRI Campus, Dehradun
4	<i>Adenanthera microsperma</i>	02	FRI Campus, Dehradun
5	<i>Aegle marmelos</i>	03	Kansro, Rajaji National Park, Uttarakhand
			Chakata Range Haldwani, Uttarakhand
			Srinagar Garhwal, Uttarakhand
6	<i>Ailanthus excelsa</i>	02	Sirsoli, Ukhimath, Kedarnath Forest Division
7	<i>Albizia chinensis</i>	02	Sahiya, Chakrata Forest Division
8	<i>Albizia julibrissin</i>	01	Arakot, Chamba, Uttarakhand
9	<i>Albizia odorotissima</i>	01	Rajpur Road Mussorie Forest Division, Uttarakhand
10	<i>Albizia procera</i>	02	Raiwala, Rajaji National Park
11	<i>Aristolochia elegans</i>	01	Jauljivi, Pithoragarh Forest Division, Uttarakhand
12	<i>Bauhinia retusa</i>	02	Dugra Forest, Bhatwara, Tehri Forest Division
13	<i>Bauhinia vahlii</i>	02	Kilmori Forest, Tehri Forest Division
14	<i>Bauhinia variegata</i>	02	FRI Campus, Dehradun
15	<i>Berberis vulgaris</i>	01	Kedar Valley, Kedarnath Forest Division, Uttarakhand
16	<i>Bischofia javanica</i>	01	Jauljivi, Pithoragarh Forest Division, Uttarakhand
17	<i>Buxus wallichiana</i>	01	Jadi, Chakrata Forest Division, Uttarakhand
18	<i>Carpinus viminea</i>	01	Mandal, Kedarnath WLS, Uttarakhand
		01	Kanchula Khark, Mandal, Kedarnath Forest Division, Uttarakhand
19	<i>Cassia glauca</i>	02	FRI Campus, Dehradun

20	<i>Cassia javanica</i>	02	FRI Campus, Dehradun
21	<i>Cassine glauca</i>	02	Ghanderdhar, Bhatwara, Tehri Forest Division
22	<i>Cedrus deodara</i>	01	Mayawati, Lohaghat Forest
23	<i>Celastrus paniculatus</i>	01	Narkota, Rudraprayag Forest Division, Uttarakhand
24	<i>Celtis australis</i>	01	Chaprali, Pauri Forest Division, Uttarakhand
25	<i>Celtis tetrandra</i>	01	Almora Forest Division
26	<i>Chukrasia tabularis</i>	02	FRI Campus, Dehradun
27	<i>Cinnamomum tamala</i>	03	Ranikhet Forest Division, Uttarakhand
28	<i>Cinnamomum camphora</i>	02	FRI Campus, Dehradun
29	<i>Cordia dichotoma</i>	02	Judo, Kalsi Forest Division
30	<i>Corylus colurna</i>	01	Vinayak, Kosi Range Nainital FD
		01	Mandal Forest, Kedarnath Wildlife Sanctuary, Uttarakhand
31	<i>Crotalaria cytisoides</i>	01	Mussoorie Road, Uttarakhand
32	<i>Cryptolepis buchananii</i>	02	Jhingardhar, Bhatwara, Tehri Forest Division
33	<i>Cupressus torulosa</i>	02	FRI Campus, Dehradun
34	<i>Dalbergia lanceolaria</i>	02	Dr. Sushila Tiwari Herbal Garden, Rishikesh
35	<i>Dalbergia sissoo</i>		Thano Range, Uttarakhand
		02	Dakpathar, Kalsi, Uttarakhand
36	<i>Delonix regia</i>	02	FRI Campus, Dehradun
37	<i>Enterolobium contortisiliquum</i>	02	FRI Campus, Dehradun
38	<i>Flacourtia indica</i>	02	Maangu, Bhatwara, Tehri Forest Division
39	<i>Fraxinus micrantha</i>		Buranskhanda, Dhanaulti, Mussoorie FD
		02	Mandal Forest, Kedarnath Wildlife Sanctuary, Uttarakhand
40	<i>Fraxinus xanthoxyloides</i>	01	Kailashpur Beat, Joshimath Range, Uttarakhand
41	<i>Grewia optiva</i>	01	Chaprali, Pauri Forest Division, Uttarakhand
42	<i>Hippophae salicifolia</i>		Upper Yamuna Forest Division, Uttarakhand
			Hanuman Chatti Badrinath, Uttarakhand
		03	Jhelam Van Panchayat, Joshimath Range, Uttarakhand
		01	Kedar Valley, Kedarnath Forest Division, Uttarakhand
43	<i>Hymenodictyon excelsum</i>	02	Ramnagar, Nanital Forest Division, Uttarakhand.
		01	Kansrao, Rajaji National Park, Uttarakhand
44	<i>Indigofera cassioides</i>	02	Thalka, Bhatwara, Tehri Forest Division

45	<i>Juglans regia</i>	01	Soni, Ranikhet Range
		02	Vinayak, Koshi Range, Nanital Forest Division, Uttarakhand.
46	<i>Jacaranda mimosifolia</i>	01	FRI Campus, Dehradun
47	<i>Kydia calycina</i>	02	Agrakhal, Narendra Nagar Forest Division
48	<i>Melia composita</i>	02	FRI Campus, Dehradun
49	<i>Oroxylum indicum</i>	03	Near Mansadevi Temple, Rajaji National Park
			Motichur , Rajaji National Park, Uttarakhand
			Rudraprayag Forest, Uttarakhand
		03	Belpadav , Tarai East Haldwani, Uttarakhand Kaladunghi Ramnagar, Uttarakhand.
50	<i>Pinus wallichiana</i>	03	Tanta Village, Dharchula Range, Uttarakhand
			Dhanaulti, Mussoorie FD, Uttarakhand
			Near Gamshali, Joshimath Range, Uttarakhand
51	<i>Punica granatum</i>	01	Mandal Forest, Kedarnath WLS
		01	Soni, Ranikhet Range Uttarakhand
52	<i>Putranjiva roxburghii</i>	02	FRI Campus, Dehradun
53	<i>Pyracantha crenulata</i>	02	Korwa, Chakrata Forest Division
54	<i>Rhododendron arboreum</i>	01	Radi Top, Upper Yamuna Forest Division, Uttarakhand
55	<i>Rubus ellipticus</i>	02	Purola, Tons Forest Division
56	<i>Schleichera oleosa</i>	01	Haridwar Forest Area
57	<i>Terminalia bellerica</i>	01	Rajaji NP
58	<i>Toona ciliata</i>	02	Motichur, Rajaji NP, Uttarakhand
			Haldwani Forest Division, Uttarakhand
59	<i>Uncaria pilosa</i>	01	Pithoragarh, Uttarakhand
Total	59 Species	111	

Seeds of *Albizia procera*, *Albizia chinensis*, *Kydia calycina*, *Dalbergia lanceolaria*, *Cordia dichotoma*, *Putranjiva roxburghii* were evaluated for germination percent, moisture content and desiccated to safe moisture level for long term conservation in the genebank at -18⁰ C.

8. Data compilation and maintenance of record

The data collected from field and laboratory experiments *i.e.*, seed collection, moisture content determination and viability test of fresh and stored seeds were compiled, sorted on quarterly basis and data entered in MS-excel for analysis.

9. Long term seed storage of seed samples at NBPGR






The well processed, cleaned, desiccated, initial viability determined seed samples of **59** forestry species (total 111 samples) were labelled and deposited in the Gene bank of ICAR, NBPGR for their long-term conservation.



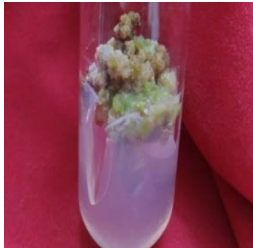

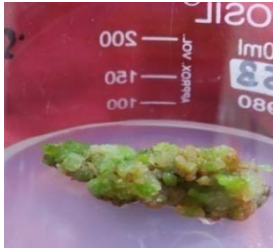
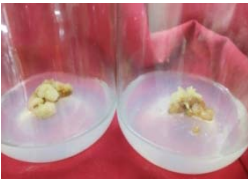
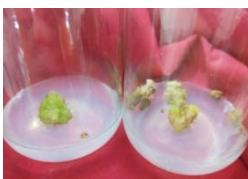
10. In-vitro storage of FGR species

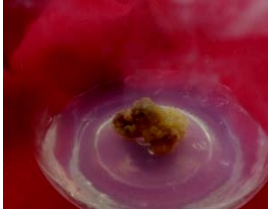
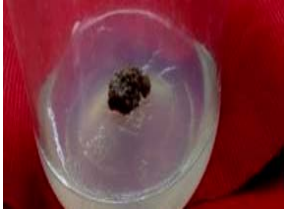

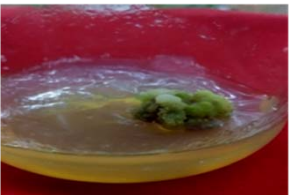


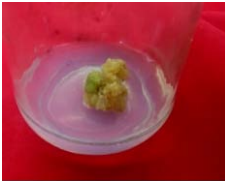
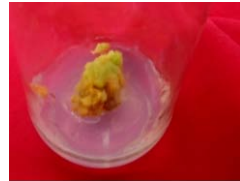
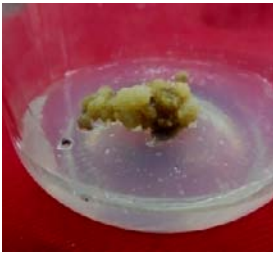
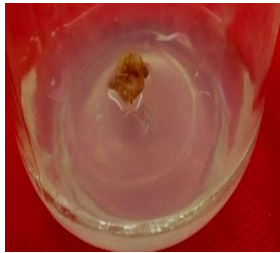
Protocols were developed for *in vitro* storage of germplasm of FGR species of very high conservation concern and ones having recalcitrant seeds along with the red listed species of FGR in the form of ‘pollens’. Experiments have been conducted for maintaining minimal growth cultures and embryo cultures of the selected species.

Under the project objectives *in vitro* experiments for storage of germplasm of FGR species have been conducted in following species till date: *Taxus contorta*, *Rhododendron arboreum*, *Quercus floribunda*, *Quercus semecarpifolia*, *Myrica esculenta*, *Acacia catechu*, *Diploknema butyraceae*, *Dodecadenia grandiflora*, *Betula utilis*, *Pittosporum eriocarpum*, *Ilex pseudo-odorata*, *Sterculia colorata*, *Citrus macroptera*, *Cyclostemon assamicus*, *Diospyros exculpta*, *Desmodium oojeinensis*, *Hippophae salicifolia*, *Albizia julibrissin*, *Aristolochia punjabensis*, *Butea peltita*, *Dysoxylum gotadhora*, *Catamixis baccharoides*, *Oroxylum indicum*, *Hymenodictyon orixense*, *Rhus parviflora*. Out of these following species were established into cultures:

Table 19: Protocols for *in vitro* storage of Germplasm of FGR species

1.	<i>Desmodium oojeinensis</i>: Seeds were procured from Forest tree seed laboratory, Silviculture Division, FRI.	
i)	<p>In vitro seed germination was achieved in liquid MS basal medium and hypocotyls, epicotyl and cotyledonary segments were used as explants for Somatic organogenesis experiments</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p><i>D. oojeinensis</i> hypocotyls, epicotyl and cotyledonary segments cultured onto different media</p> </div> <div style="text-align: center;">  <p>Somatic organogenesis from calli originated from hypocotyls of <i>D. Oojeinensis</i></p> </div> </div>	
ii)	<p>Callus Culture: Callus cultures were generated from cotyledons, epicotyls and hypocotyls of <i>in vitro</i> germinated seedlings on different MS medium combinations. The cultures were multiplied in MS medium supplemented with different PGRs and additives</p> <p><i>In vitro</i> response:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Organogenesis in Callus culture</p> </div> <div style="text-align: center;">  <p>Shoot initials in Glutamine (15 mg/l)</p> </div> <div style="text-align: center;">  <p>Formation of shoot Initials</p> </div> </div>	
iii)	<p>Multiplication of Calli: Calli multiplication is underway on MS + 0.5 (mg/l) BAP + 0.5 mg/l NAA</p>	

	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Callus under multiplication</i></p>															
iv)	<p>Sub-culture of Calli: Callus cultures are being maintained on MS+ 1(mg/l) BAP+ AgNO₃ for multiplication and storage.</p>															
v)	<p>Slow Growth Experiments for medium term storage</p>															
a)	<p>Shape of the culture vessel: Four types of culture vessels were used to optimize an apt culture vessel type for slow growth proliferation: viz. Jam Bottles, Phyta jars, Conical flasks and test tubes on MS + 0.5 (mg/l) BAP + 0.5 (mg/l) NAA</p>															
	<p><i>In vitro</i> response: The most apt culture vessel for achieving slow growth proliferation was phyta jar, while conical flask was the least favoured one.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>S.No.</th> <th>Culture vessel</th> <th>Average callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Phyta jar</td> <td>1.40</td> </tr> <tr> <td>2</td> <td>Test tube</td> <td>7.32</td> </tr> <tr> <td>3</td> <td>Jam bottle</td> <td>13.09</td> </tr> <tr> <td>4</td> <td>Conical flask</td> <td>31.75</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around; margin-top: 10px;">     </div> <p style="text-align: center;"> <i>Callus in Phyta jar</i> <i>Callus in Test tube</i> <i>Callus in Jam bottle</i> <i>Callus in conical flask</i> </p>	S.No.	Culture vessel	Average callus multiplication rate	1	Phyta jar	1.40	2	Test tube	7.32	3	Jam bottle	13.09	4	Conical flask	31.75
S.No.	Culture vessel	Average callus multiplication rate														
1	Phyta jar	1.40														
2	Test tube	7.32														
3	Jam bottle	13.09														
4	Conical flask	31.75														
b)	<p>Photoperiod conditions: Callus was kept under light and dark conditions in the previously optimized media (MS + 0.5 (mg/l) BAP + 0.5 (mg/l) NAA)</p>															
	<p><i>In vitro</i> response: Although callus multiplication under dark was found to be more beneficial for slow growth but the calli were found to be brownish while the calli under light were green.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>S. No.</th> <th>Photo conditions</th> <th>Average callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Light condition</td> <td>8.83</td> </tr> <tr> <td>2</td> <td>Dark condition</td> <td>5.95</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around; margin-top: 10px;">   </div> <p style="text-align: center;"> <i>Callus under dark condition</i> <i>Callus under light condition</i> </p>	S. No.	Photo conditions	Average callus multiplication rate	1	Light condition	8.83	2	Dark condition	5.95						
S. No.	Photo conditions	Average callus multiplication rate														
1	Light condition	8.83														
2	Dark condition	5.95														
c)	<p>Temperature: Two sets of experiment were planned. In first one, callus was kept under low temperature i.e. 15°C and in second one callus was kept under room temperature i.e. 25°C on MS +</p>															

	0.5 (mg/l) BAP + 0.5 (mg/l) NAA and left for 45 days to check the multiplication rate.																
	<p>In vitro response: The suitable temperature for achieving slow growth proliferation was 25°C whereas 15°C showed browning of callus.</p> <table border="1"> <thead> <tr> <th>S.No.</th> <th>Temperature</th> <th>Average callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>25°C</td> <td>10.59</td> </tr> <tr> <td>2</td> <td>15°C</td> <td>16.36</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around;">   </div> <p style="text-align: center;"><i>Callus kept under 25°C and 15°C respectively</i></p>		S.No.	Temperature	Average callus multiplication rate	1	25°C	10.59	2	15°C	16.36						
S.No.	Temperature	Average callus multiplication rate															
1	25°C	10.59															
2	15°C	16.36															
d)	<p>Ethylene inhibitors: A low ethylene concentration (controlled by ethylene inhibitors i.e. Silver nitrate (AgNO₃)) has been applied for improving in vitro morphogenesis. Four sets of AgNO₃ were prepared with different concentrations. Callus was subcultured on MS + 0.5 (mg/l) BAP + 0.5 (mg/l) NAA and left for 45 days to check the multiplication rate.</p> <p>In vitro response: Growth was found to decline with addition of AgNO₃. Appreciable results were not obtained with 10% AgNO₃ but 20% and 30% showed comparable results. 20% AgNO₃ was found to be the best concentration.</p> <table border="1"> <thead> <tr> <th>S. No.</th> <th>AgNO₃</th> <th>Average callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Control</td> <td>20.74</td> </tr> <tr> <td>2</td> <td>10%</td> <td>12.76</td> </tr> <tr> <td>3</td> <td>20%</td> <td>3.27</td> </tr> <tr> <td>4</td> <td>30%</td> <td>5.81</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around;">     </div> <p style="text-align: center;"><i>Control (No AgNO₃) 10% AgNO₃ 20% AgNO₃ 30% AgNO₃</i></p>		S. No.	AgNO ₃	Average callus multiplication rate	1	Control	20.74	2	10%	12.76	3	20%	3.27	4	30%	5.81
S. No.	AgNO ₃	Average callus multiplication rate															
1	Control	20.74															
2	10%	12.76															
3	20%	3.27															
4	30%	5.81															
e)	<p>Strength of MS media: The calli were multiplied on half and full strength MS to see the effect of media strength in order to have an apt media for culture maintenance.</p> <p>In vitro response: Strength reduction of the culture media had insignificant effect on the multiplication rate of the calli suggesting that a full strength MS medium can also be used for the slow growth storage of <i>D. oojinensis</i></p> <table border="1"> <thead> <tr> <th>S. No.</th> <th>Strength of MS</th> <th>Average callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Half</td> <td>7.90</td> </tr> <tr> <td>2</td> <td>Full</td> <td>8.3</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around;">   </div> <p style="text-align: center;"><i>Callus in half MS Callus in full MS</i></p>		S. No.	Strength of MS	Average callus multiplication rate	1	Half	7.90	2	Full	8.3						
S. No.	Strength of MS	Average callus multiplication rate															
1	Half	7.90															
2	Full	8.3															
f)	<p>Abscisic acid: ABA was used in the concentration range of 250-750µl per litre medium</p> <p>In vitro response:</p> <table border="1"> <thead> <tr> <th>S. No.</th> <th>ABA</th> <th>Average Callus multiplication rate</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Control</td> <td>11.20</td> </tr> <tr> <td>2</td> <td>250µl</td> <td>9.78</td> </tr> <tr> <td>3</td> <td>500µl</td> <td>7.74</td> </tr> <tr> <td>4</td> <td>750µl</td> <td>6.86</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around;">   </div> <p style="text-align: center;"><i>Control (no ABA) 750 µl ABA</i></p>		S. No.	ABA	Average Callus multiplication rate	1	Control	11.20	2	250µl	9.78	3	500µl	7.74	4	750µl	6.86
S. No.	ABA	Average Callus multiplication rate															
1	Control	11.20															
2	250µl	9.78															
3	500µl	7.74															
4	750µl	6.86															

750µl concentration of ABA was found to be better for slow growth storage. The application of ABA resulted in reduction of multiplication rate in all the concentrations with an insignificant difference which shows that ABA acts as growth inhibitor of *D. oojeinensis*. But ABA is not a favourable slow growth storage agent for *D. oojeinensis* because it resulted in predominant browning of callus which was not recoverable.

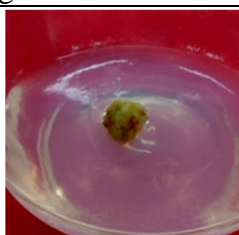
g) Osmotic potential preservation-A) Sucrose concentration

The calli were multiplied on 1% - 4% sucrose to see the effect of media strength in order to have an apt media for culture maintenance.

***In vitro* response:**

According to the data, the best suitable concentration of sucrose for slow growth storage was found to be 30 gram while 10 g and 40 g resulted in browning.

S. No	Sucrose	Average callus multiplication rate
1	10 g	16.95
2	20 g	7.88
3	30 g	3.34
4	40 g	10.31



Callus in 30g sucrose



Callus in 10g sucrose

Osmotic potential preservation-B) Sorbitol

The calli were multiplied on 1% - 5% sorbitol to see the effect of media strength in order to have an apt media for culture maintenance.

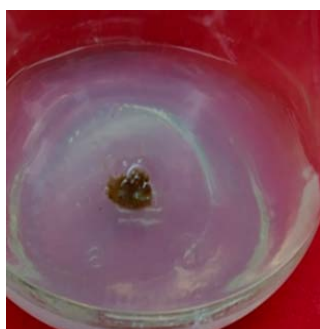
***In vitro* response:**

The best suitable concentration of Sorbitol for slow growth storage was found to be 5%. Although addition of Sorbitol resulted in reduction in multiplication rate of *D. oojeinensis* but due to browning in all the concentrations, it was not considered the favourable agent for slow growth, proving that Sorbitol had toxic effect in the growth.

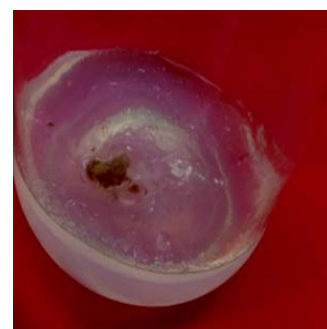
S. No.	Sorbitol	Average Callus multiplication rate
1	Control	11.37
2	1%	11.07
3	3%	9.98
4	5%	5.98



Control (No sorbitol)



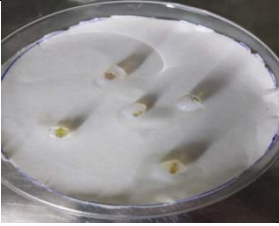







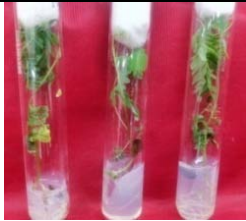
1% sorbitol

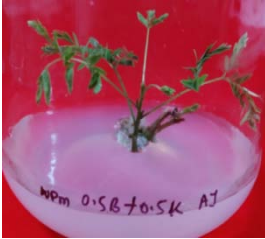

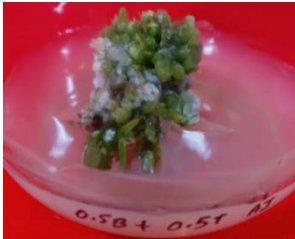









5% sorbitol



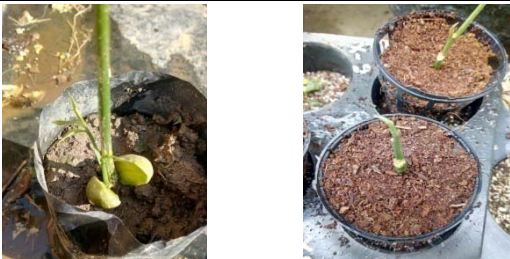


Osmotic potential preservation-C) Poly Ethyl Glycol (PEG)







	<p>The calli were multiplied on 200µl- 500µl PEG to see the effect of media strength in order to have an apt media for culture maintenance</p> <p><i>In vitro</i> response:</p> <table border="1"> <thead> <tr> <th>S. No</th> <th>PEG</th> <th>Average multiplication rate of callus</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Control</td> <td>29.31</td> </tr> <tr> <td>2</td> <td>250µl</td> <td>14.91</td> </tr> <tr> <td>3</td> <td>375µl</td> <td>7.36</td> </tr> <tr> <td>4</td> <td>500µl</td> <td>3.64</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around;">   </div>	S. No	PEG	Average multiplication rate of callus	1	Control	29.31	2	250µl	14.91	3	375µl	7.36	4	500µl	3.64
S. No	PEG	Average multiplication rate of callus														
1	Control	29.31														
2	250µl	14.91														
3	375µl	7.36														
4	500µl	3.64														
vi)	<p style="text-align: center;"><i>Control (No PEG)</i> <i>500 µl PEG</i></p> <p>Preliminary trials on long term storage: As an attempt towards long term storage, friable calli were incorporated into synthetic beads containing Sodium-alginate (4% - 7%), anhydrous CaCl₂ (4%-5%), 1.5% sucrose in half- MS media.</p> <p><i>In vitro</i> response: Calli beads were successfully formed using 4% Sodium-alginate and 5% anhydrous CaCl₂. They were kept on moist filter paper and will be monitored for further storage.</p> <div style="text-align: right;">  <p><i>Synthetic seed beads of calli</i></p> </div>															
vii)	<p>Subculture of Calli: Callus cultures are being maintained on MS+ 1(mg/l) BAP+ AgNO₃ for multiplication and storage.</p> <div style="text-align: center;">  <p><i>Callus maintenance in 1(mg/l) BAP+ AgNO₃</i></p> </div>															
2.	<p><i>Hippophae salicifolia</i></p>															
i)	<p><i>In vitro</i> Seed germination: It has been achieved in liquid MS basal medium and seedling explants are being multiplied for further proliferation. Callus formation followed by somatic embryogenesis trials has also been initiated.</p> <div style="display: flex; justify-content: space-around;">   </div> <p style="text-align: center;"><i>In vitro</i> multiplication of <i>H. salicifolia</i> shoots</p>															







ii	<i>In vitro</i> multiplication of shoots:
	<i>In vitro</i> shoot multiplication in MS+1.0(mg/l) BAP+0.5(mg/l) KIN (optimized previously) for slow growth and culture maintenance is underway.
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Microshoot in MS+1.0 mg/l BAP+0.5mg/l KIN for culture maintenance</i></p>
iii)	<i>In vitro</i> rooting:
	<i>In vitro</i> rooting had been initiated in liquid and solid medium and is underway.
iv)	Experiment with medium term storage
	An increase in the duration of subculture to 6-8weeks led to browning of shoots in all the cultures. The cultures (30-40%) resumed growth after being subculture in fresh multiplication medium.
	 <p>A: Browning of shoots due to extended subculture duration B: Emergence of green shoots after subculture to fresh medium C: Multiplication of shoots</p>
3.	<i>Albizia julibrisin</i>
i	<i>In vitro</i> seed germination: Seeds of <i>A. julibrisin</i> were sterilised and inoculated.
	<p><i>In vitro</i> response: The seeds have germinated into healthy seedlings. Further experiments will be carried out to establish more cultures.</p>  <p style="text-align: right;"><i>In vitro</i> germinated seedlings of <i>A. julibrisin</i></p>
ii	<i>In vitro</i> shoot multiplication: <i>In vitro</i> raised shoots from seedlings were further multiplied in MS and WPM medium supplemented with different growth regulators (BAP, IBA, TDZ, NAA) combinations. Overall 13 medium combinations were used.




	<p><i>In vitro</i> response: Among different medium tried, MS+2.0 mg/l BAP+0.5 mg/l IBA led to vigorous shoot multiplication. Single prominent shoot was developed in WPM+0.5 mg/l BAP+0.5 mg/l KIN and MS+1.5 mg/l BAP+0.5 mg/l TDZ formed vigorous calli intensity with tiny microshoot initials</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p><i>Shoot multiplication in WPM+0.5BAP+0.5KIN</i></p> </div> <div style="text-align: center;">  <p><i>Shoot multiplication in MS+2.0BAP+0.5IBA</i></p> </div> <div style="text-align: center;">  <p><i>Shoot multiplication in MS+0.5BAP+0.5TDZ</i></p> </div> </div>
iii)	<p><i>In vitro</i> proliferation and elongation of shoots: <i>In vitro</i> raised shoots are maintained through proliferation, shoot elongation was done on MS+2.5 (mg/l) BAP+0.25(μl) GA₃</p>
	<p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>Microshoot multiplication</i></p> </div>
iv)	<p><i>In vitro</i> rooting</p>
	<p><i>In vitro</i> raised shoots were transferred to half MS + 0.5-1.5mg/l IBA+ clerigel+ 10(mg/l) coumarine for root induction.</p> <p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>No root initials were formed in the applied PGR combinations</i></p> </div>
v)	<p><i>In vitro</i> medium term storage using synthetic seeds</p>
	<p><i>In vitro</i> raised shoot buds were used to create synthetic seeds using 3% sodium alginate and 100mM anhydrous CaCl₂ and after a storage of eight weeks were allowed to regrow in the optimized medium (MS+1 mg/l BAP+ 0.5 mg/l KIN).</p>





	<p><i>In vitro</i> response:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>a</p> </div> <div style="text-align: center;">  <p>b</p> </div> </div> <p>a- Preparation of synthetic seeds for medium term storage b- Regrowth of shoot buds in encapsulated beads after eight weeks</p>
4.	<i>Aristolochia punjabensis</i>
i)	<p><i>In vitro</i> bud induction Nodal segments were inoculated on MS+3 (mg/l) BAP+ 0.5 (mg/l) NAA.</p> <p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>In vitro axillary bud initiation and proliferation</i></p> </div>
ii)	<p><i>In vitro</i> multiplication of shoots: Shoots are being maintained on multiplication media MS+1 (mg/l) BAP</p> <p><i>In vitro</i> response: The multiplication media for <i>A. punjabensis</i> has been optimised and the shoots are being proliferated.</p> <div style="text-align: right;">  <p><i>In vitro shoot multiplication</i></p> </div>
iii)	<p><i>In vitro</i> callus initiation and multiplication: The callus initiated from the leaf segments is under propagation on MS + 1 (mg/l) BAP + AgNO₃ for culture maintenance.</p> <p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>Callus maintenance in 1(mg/l) BAP+ AgNO₃</i></p> </div>
iv)	<p><i>In vitro</i> medium term storage using synthetic seeds Preparation of synthetic seeds of <i>A. punjabensis</i> for medium term storage is underway.</p>
5.	<i>Butea peltita</i>
i)	<p><i>In vitro</i> induction of callus and multiplication: The leaves were inoculated on different media (MS media supplemented with BAP and 2,4-D for callus induction.</p>

	<p><i>In vitro</i> response:</p> 
ii)	<p><i>In vitro</i> callus maintenance</p> <p>The callus is being maintained on MS+1 (mg/l) BAP + AgNO₃</p>
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Callus maintenance in 1(mg/l) BAP+ AgNO₃</i></p>
iii)	<p><i>In vitro</i> callus maintenance</p> <p>The callus is being maintained and stored in MS+1 (mg/l) BAP + AgNO₃</p>
6.	<p><i>Dysoxylum gotadhora</i></p>
i)	<p>Seed germination in pots</p> <p>Seed collection Seeds were collected from trees growing in FRI campus and were germinated in hycu pots under green house conditions to ensure availability of explants for <i>In vitro</i> experiments.</p> 
ii)	<p><i>In vitro</i> seed induction: <i>In vitro</i> seed inoculation in basal MS.</p> <p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Gotadhora</i> <i>In vitro</i> seed germination of D.</p>
iii)	<p>Optimization of <i>in vitro</i> surface sterilization:</p> <p>Sterilization optimization experiment was conducted on the nodal segments using NaOCl in variable concentrations (1%, 2%, 3%, 4%) at two time periods (1min and 2 min) in MS growth media with different concentrations of BAP.</p> <p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Fungal contamination in the inoculated nodal</i></p>

iv)	<p>Callus induction from seed cotyledons: The seed cotyledons were inoculated on MS+ (1-5) mg/l TDZ+ 2(mg/l) 2,4-D for callus induction and on MS+ 1 (mg/l) BAP + 0.05 mg/l (IBA and NOA) for further proliferation.</p>
	<p><i>In vitro</i> response: Successful callus induction occurred on MS+ 4 (mg/l) TDZ + 2 (mg/l) 2,4-D and callus proliferation is ongoing.</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p style="text-align: center;"><i>Cotyledonary callus proliferation Inoculation of seed</i></p>
v)	<p>Embryo culture</p>
	<p>The zygotic embryos isolated from the seeds were inoculated on MS+ 2-3 mg/l 2,4-D+0.01 mg/l KIN in petriplates for embryogenesis after their surface sterilization.</p>
	<p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>In vitro growth of embryos</i></p> </div>
vi)	<p><i>In vitro</i> medium term storage using synthetic seeds</p>
	<p>Preparation of synthetic seeds of <i>A. punjabensis</i> for medium term storage is underway.</p>
7.	<p><i>Catamixis baccharoides</i></p>
i)	<p><i>In vitro</i> shoot initiation and multiplication: B₅ Media- 0.1-0.5 (mg/l) BAP were used</p>
	<p><i>In vitro</i> response:</p> <div style="text-align: center;">  <p><i>In vitro response in C. baccharoides</i></p> </div>
ii)	<p><i>In vitro</i> callus induction: In vitro callus induction was tried on MS media with different combinations of 2,4-D, BAP and IAA</p>
	<p><i>In vitro</i> response:</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p style="text-align: center;"><i>Callus formation in different media combinations</i></p>
iii)	<p><i>In vitro</i> seed culture</p>
	<p>The seeds of <i>C. baccharoides</i> collected from Byasi forest rangewere inoculated on basal MS in petriplates after their surface sterilization.</p>

	<p><i>In vitro</i> response: The seeds sprouted with an average 60% germination.</p>  <p style="text-align: center;"><i>In vitro seed inoculation</i></p>
iv)	<i>In vitro</i> shoot multiplication and medium term storage using synthetic seeds
	Shoot multiplication of the germinated seedlings and use of apical shoots for synthetic seed preparation and storage is underway.
8)	<i>Oroxylum indicum</i>
i)	<i>In vitro</i> seed germination
	The seeds collected from the seed laboratory, FRI were inoculated on basal MS after overnight dip in 50µM GA ₃ to overcome seed dormancy and surface sterilization.
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>In vitro seed germination in O. indicum</i></p>
ii)	Subculture of the <i>in vitro</i> germinated seedlings
	Germinated seedlings were subcultured in MS+ 0.5 mg/l BAP+ AgNO ₃ for further growth.
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Seedling growth in O. indicum</i></p>
iii)	<i>In vitro</i> shoot multiplication
	MS medium supplemented with different growth regulators (BAP, TDZ, NAA) combinations (08 medium combinations) were used.
	<p><i>In vitro</i> response: Among these, MS+0.5 - 2.0 mg/l BAP developed multiple short heighted shoots in approximately all combinations. In presence of TDZ, MS+2.0 mg/l BAP+0.5 mg/l TDZ only organogenesis was initiated with no shoot development. MS+1.5 mg/l BAP+0.25 mg/l NAA developed single long shoots</p>  <p style="text-align: center;"><i>Microshoot multiplication in MS+2.0BAP</i></p>  <p style="text-align: center;"><i>Microshoot multiplication in MS+2.0BAP+0.5TDZ</i></p>  <p style="text-align: center;"><i>Microshoot multiplication in MS+1.5BAP+0.5NAA</i></p>
iv)	<i>In vitro</i> shoot multiplication under slow growth conditions

	<p><i>In vitro</i> shoot multiplication in MS medium supplemented with 0.5(mg/l) KIN 6 is underway and different <i>in vitro</i> treatments being tested for slow growth of cultures. Different slow growth conditions are:</p> <ol style="list-style-type: none"> 1. 1/2 MS + 0.5(mg/l) KIN 2. 1/4 MS+ 0.5(mg/l) KIN 3. MS+ 0.5(mg/l) KIN + 50(gm/l) sucrose 4. MS+ 0.5(mg/l) KIN + 10(gm/l) mannitol
	<p><i>In vitro</i> response:</p>  <p>a) Inoculation in 1/2 and 1/4MS+0.5(mg/l) KIN respectively b) MS + 0.5(mg/l) KIN+ 5% sucrose and MS + 0.5mg/l KIN + 10gm/l Mannitol respectively.</p>
v)	<i>In vitro</i> shoot multiplication
	<i>In vitro</i> shoot multiplication in MS medium supplemented in 0.5(mg/l) KIN + glutamine.
	<p><i>In vitro</i> response:</p>  <p><i>Multiplication in MS + 0.5(mg/l) KIN + glutamine</i></p>
vi)	<i>In vitro</i> rooting
	<i>In vitro</i> raised shoots were transferred to half MS + 0.5-1.5mg/l IBA+ clarigel+ 10mg coumarine for root induction.
	<p><i>In vitro</i> response:</p>  <p><i>Root initiation</i></p>
vii)	<i>In vitro</i> medium term storage using synthetic seeds
	<i>In vitro</i> raised shoot buds were used to create synthetic seeds using 3% sodium alginate and 100mM anhydrous CaCl ₂ and after a storage of eight weeks were allowed to regrow in the optimized medium (MS+ 0.5 mg/l KIN+ 25mg/l glutamine).

	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Preparation of synthetic seed & germination</i></p>
viii)	Hardening of the rooted plantlets
	Rooted plantlets were acclimatized and hardened in hardening chambers in sterilized coco-pit mixture.
9.	<i>Hymenodictyon orixense</i>
i)	<p><i>In vitro</i> seed germination: Seeds collected from Forest Tree Seed Laboratory, FRI Dehradun were inoculated in basal MS after their surface sterilization</p> <p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>In vitro seed germination in Hymenodictyon orixense</i></p>
ii)	<i>In vitro</i> shoot multiplication
	Seedlings germinated from the seeds were proliferated on different media and PGR combinations. <i>In vitro</i> shoot multiplication in MS medium supplemented with different growth regulators (BAP, KIN, NAA) combinations was carried out. Altogether 08 medium combinations were used
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>Microshoot multiplication in MS+0.25KIN</i></p>  <p style="text-align: center;"><i>Microshoot multiplication in MS+0.5BAP+0.25KIN</i></p>
iii)	<i>In vitro</i> rooting:
	<i>In vitro</i> rooting was optimized using various combinations of IAA and NAA along with 0.025 (mg/l) KIN in each.

***In vitro* response:**



a & b -*In vitro* rooting in 25µl IAA and NAA respectively (L-R)
c & d- *In vitro* rooting in 100µl IAA and NAA respectively (L-R).

iv) Hardening of the rooted plantlets

Rooted plantlets were acclimatized and hardened in hardening chambers in sterilized coco-pit mixture.

***In vitro* response:**



In vitro rooting in *H. orixense*

10. *Rhus parviflora*

i) *In vitro* seedling germination and proliferation

Seeds collected from Forest Tree Seed Laboratory, FRI Dehradun were inoculated in basal MS after their surface sterilization and seedlings germinated from the seeds were proliferated on MS+ 2 (mg/l) BAP+ 0.5 (mg/l) NAA for shoot multiplication

***In vitro* response:**



In vitro seed germination of *R. parviflora*


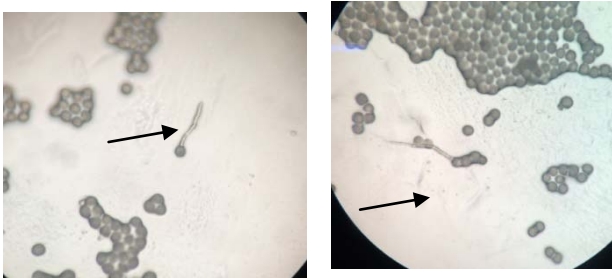

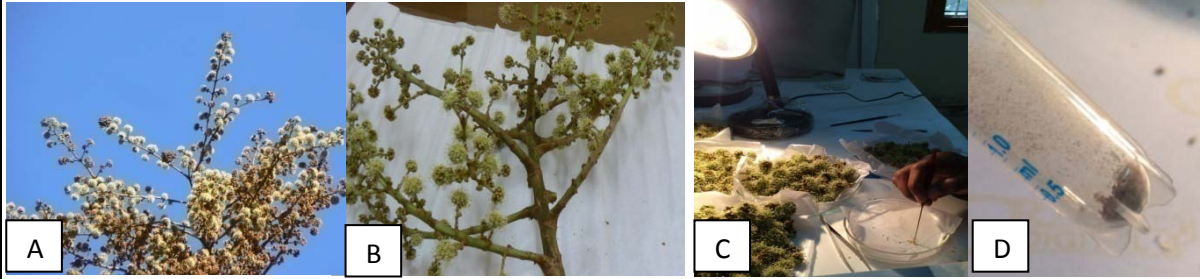
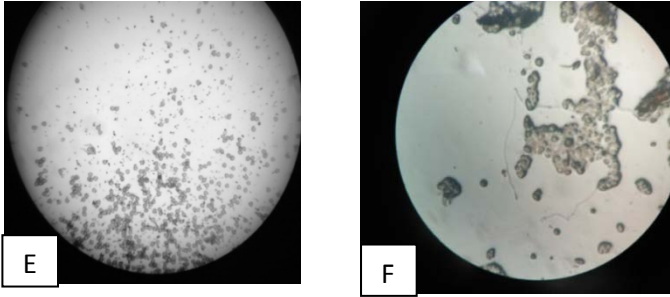
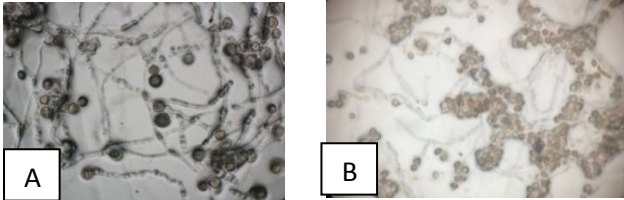
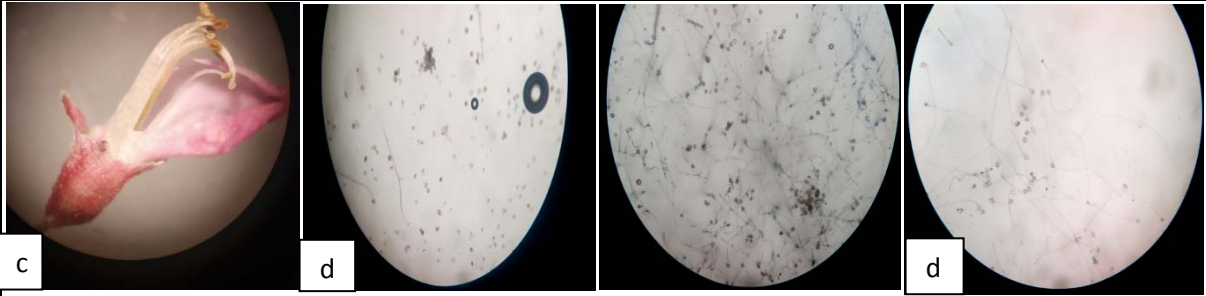
11.	<i>Diploknemma butyraceae</i>
i)	<i>In vitro</i> apical bud initiation and proliferation
	Dormant apical buds maintained <i>in vitro</i> were revived using MS+3(mg/l) BAP+0.5(mg/l)NAA and were proliferated further
	<p><i>In vitro</i> response:</p>  <p style="text-align: center;"><i>In vitro</i> sprouting of dormant apical buds</p>
ii)	<i>In vitro</i> bud initiation
	<i>In vitro</i> apical bud initiation and proliferation is going on.

Table 20: Pollen Stage Experiments:

1.	<i>Diploknema butyraceae</i>
	<p>Pollen germination trials were conducted on liquid and solid B&K medium (1-15% sucrose). While no germination was found on liquid media, all the solid media combinations had negligible amount of germination. Pollens of such low viability are difficult to be stored. Further trials will be conducted in the next flowering season.</p>  <p style="text-align: center;"><i>Poor germination of pollen in D. Butyraceae; only a few pollen germinated</i></p>
2.	<i>Butea pellita</i> Syn <i>Meizotropis pellita</i>
	<p>Pollen tubes of different lengths were observed clearly showing viability of the pollens. However, the cuttings could not survive under these conditions and dried off with time</p>  <p style="text-align: center;"><i>B. pellita</i> Floral buds Stems bearing floral buds</p>

3.	<p><i>Heteropanax fragrans</i>: <i>In vitro</i> pollen tube germination of fresh as well as dried pollens was checked on different types of media. Germination percentage was very poor (<10%) in all the media tested and no germination at all was found in the higher concentrations. The viability decreased further (<4%) after storage in liquid nitrogen (-196 deg C) for different durations. <i>The pollen in this species could not be stored at such a low viability.</i></p> 
	 <p style="text-align: center;"><i>Collection, processing and in vitro viability assessment of H. fragrans pollens.</i></p>
4.	<p><i>Sterculia colorata</i>: Flowers were collected during March. Anthers were subjected to dehiscence under lamp to collect pollens. Initial moisture content was determined using the constant temperature oven method and was found to be 28%. <i>In vitro</i> pollen tube germination was checked on different types of media with varying sucrose (10 % and 15 %) concentrations on modified B&K medium and germination percentage of 70% was found on media with 10% sucrose. Pollens were stored in liquid nitrogen for two hours and germination percentage was checked again. Few pollen grains were kept at room temperature as control. Very poor germination percentage was found in the control set while the ones kept in LN had the germination percentage as before. Pollen of <i>Heteropanax fragrans</i>, <i>Sterculia colorata</i> are being stored in liquid nitrogen. Further experiments will be done after the fresh collections are made during the favourable seasons.</p>  <p style="text-align: center;"><i>In vitro germination of S. colorata pollens before (A) and after (B) storage in LN</i></p>
5.	<p><i>Desmodium oojeinensis</i>: The floral buds of <i>Desmodium oojeinensis</i> were collected from the Bambusetum, FRI, Dehradun and the anther were subjected to dehiscence which yielded pollens of microscopic size. With an average moisture content of 18%, the pollen viability was tested on B& K medium on varying sucrose concentration (5 % -20 %).</p>
	<p>Response: While the overall germination percentage was between 10-20, the best</p>

germination percentage of 50% was found in media with 15% sucrose concentration. More experiments will be done for pollen storage with fresh collections.



of floral bud under stereo zoom

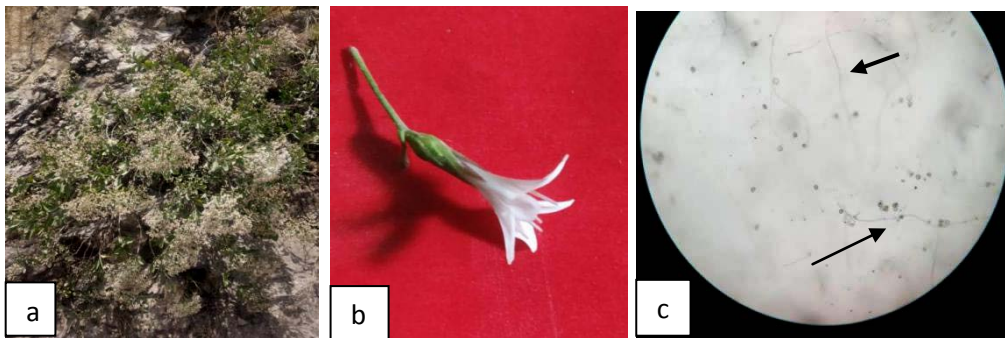
ollen grains

germination on 15% sucrose concentration on B & K medium

germination on other sucrose concentrations on B & K medium

6. *Catamixis baccharoides*: The floral buds of *C. baccharoides* were collected from the Byasi forest range and the pollens were kept overnight at 103°C in hot air oven for moisture determination. With an average moisture content of 20%, the pollens were subjected to viability test via germination test on B & K medium (5%, 10%, 15% and 20% sucrose variation). Scanty to nil germination was found in all the cases making them unfit for storage in the liquid nitrogen

***In vitro* response:**



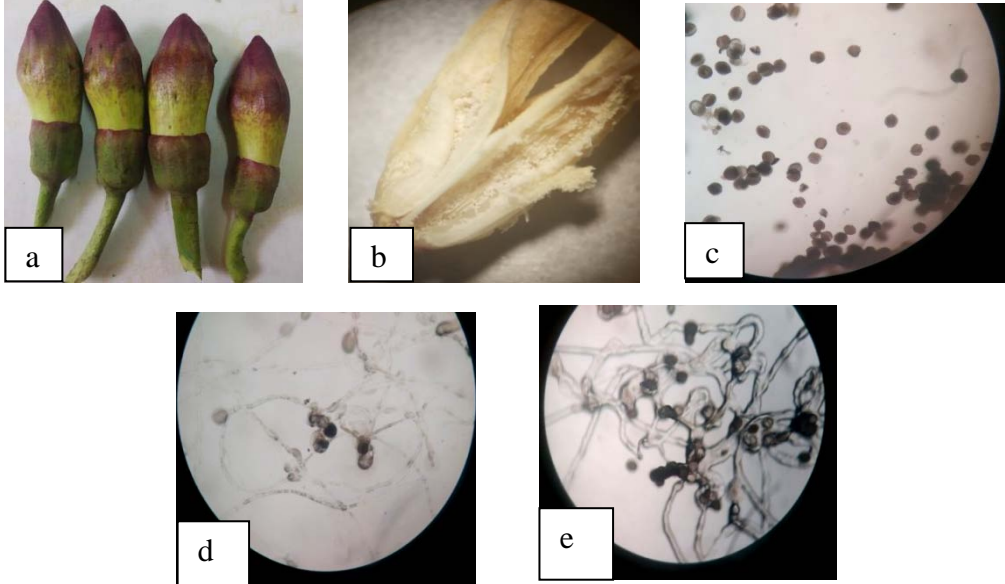
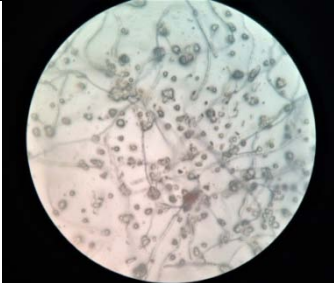
a- *C. baccharoides* flowering in the Byasi forest range
 b- Floral buds
 c- Few pollen tubes germinating

7. *Oroxylum indicum*: The floral buds of *O. indicum* were collected from the plantations near the tissue culture laboratory, green house, and the pollens were kept overnight at 103°C in hot air oven for moisture determination. The average moisture content was found to be 28%. The pollens were subjected to viability test via germination test on different media types:

- 1) B & K media: 5-20% sucrose (M1)
- 2) Media with gelatin & CaCl₂ (M2)
- 3) Media with KCl (M3)

***In vitro* response:** The germination percentages varied in different media:

- 1) M1- No germination in all concentrations of sucrose.
- 2) M2- ~20% germination
- 3) M3- ~98% germination

	 <p>a- Floral buds of <i>O. indicum</i> b- Anther with pollens as visible under the stereozoom c- 0% germination in B & K media d- Germination in M2 e- Germination in M3</p>
<p>8.</p>	<p><i>Alstonia scholaris</i> The floral buds of <i>A. scholaris</i> were collected from Haridwar forest area and the pollens were kept overnight at 103°C in hot air oven for moisture determination. With an average moisture content of 25%, the pollens were subjected to viability test via germination test on B & K medium (5%, 10%,15% and 20% sucrose variation) and M2 (gelatine media) and M3 (Arabidopsis media). Above 90% germination was found BK media with 10% sucrose and M3 while rest had no germination.</p>
	<p><i>In vitro</i> response:</p>  <p><i>Pollen germination in Alstonia</i></p>
<p>9.</p>	<p><i>Mahonia jaunsarensis</i>: Floral buds were collected from botanical garden at FRI. With an average moisture content of 20%, the pollens were subjected to viability test via germination on B & K medium (different concentration of sucrose, calcium and boric acid) and M2 (gelatin medium) and M3 (Arabidopsis medium). Approx. 24-25% germination was observed in BK medium with 15% sucrose and 20% calcium nitrate. Finally the collected anthers with pollen were stored in cryo-conditions</p>

***In vitro* response:**



Mahonia jaunsarensis pollen germination

10.

Sapium insigne:

Floral buds were collected from botanical garden at FRI. After moisture determination, pollens were subjected to germination on B & K medium (different concentration of sucrose, calcium and boric acid) and M2 (gelatin medium) and M3 (Arabidopsis medium). Approx. 33% germination was observed in BK medium with 15% sucrose and 20% boric acid, with pollen tubes visible as short protuberances. Finally the collected anthers with pollen were stored in cryo-conditions

***In vitro* response:**



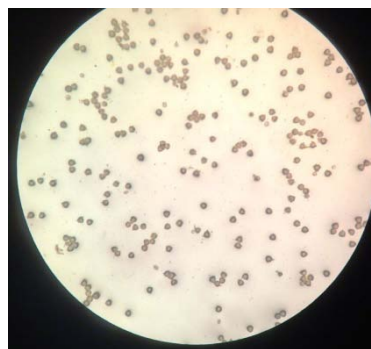
Sapium insigne pollen germination

11.

Sophora mollis: Floral buds were collected from botanical garden at FRI.

After moisture determination, pollens were subjected to germination on B & K medium (different concentration of sucrose, calcium and boric acid) and M2 (gelatin medium) and M3 (Arabidopsis medium). However germination was very poor in this species and pollens were stored as such in cryo-conditions.

***In vitro* response:**



Pollen germination test in S. mollis

12. *Buxus wallichiana*: Floral buds were collected from botanical garden at FRI. After moisture determination, pollens were subjected to germination on B & K medium (different concentration of sucrose, calcium and boric acid) and M2 (gelatin medium) and M3 (Arabidopsis medium). However germination was very poor in this species and pollens were stored as such in cryo-conditions.

***In vitro* response:**



Pollen germination test in Buxus wallichiana

13. *Crateva adansonii*:

The floral buds of *C. adansonii* were collected from the tree near the Botanical Garden, FRI in the month of August. The average moisture content was found to be 25% and 100% in vitro pollen tube germination was found on B&K media with 10 % sucrose and BK 15% sucrose.

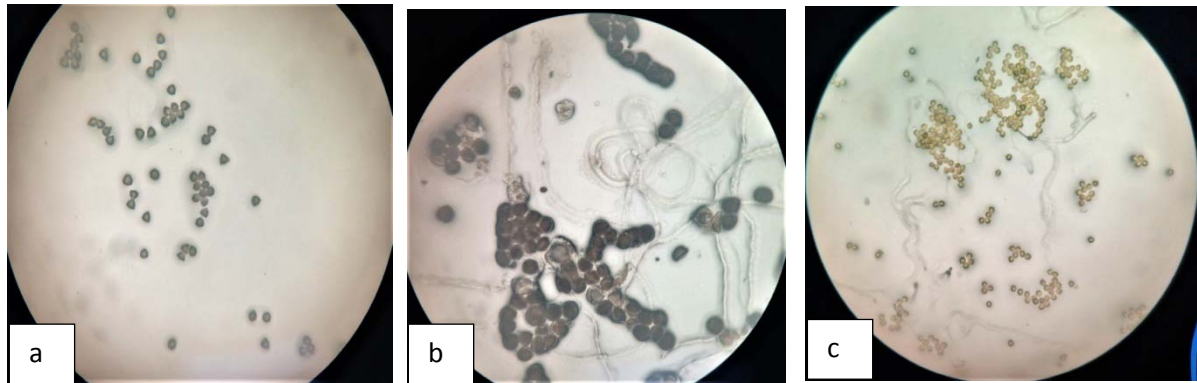


Pollen germination test in Crateva adansonii

Periodic viability of stored pollens

Species	Initial Moisture content	Medium for pollen germination	% germination	Remarks
<i>Heteropanax fragrans</i>	18%	media with varying Boric acid (50-250mg/l) and Sucrose (1-18%) conc.	very poor (<10%)	No germination found in repeated trials in all media combinations.
<i>Oroxylum indicum</i>	28%.	<i>Arabidopsis</i> standard media	98-100%	≈20% viability after 6 months in LN
<i>Sterculia colorata</i>	28%	B & K media with 10% sucrose	70%	repeat in coming season

<i>Diploknema butyraceae</i>	18%	B&K medium (1-15% sucrose)	negligible	No germination found in repeated trials in all media combinations
<i>Butea pelltita</i>	22%	B&K media with 15% sucrose	>90%	No germination, 6 months in LN
<i>Rauwolfia serpentina</i>	20%	B& K medium with 15% sucrose	>80%	pollen too less
<i>Crateva adansonii</i>	25%	B & K media with 10 % sucrose and 15% sucrose	90-100%	18-20% viability, 3months in LN



a- *B. pelltita* pollen germination (0%) during periodic viability testing
b- *O. indicum* pollen germination (20%) during periodic viability testing
c- *C. adansonii* pollen germination (20%) during periodic viability testing

C. FGR Characterization

a. MOLECULAR CHARACTERIZATION

1. Collection of samples

Samples of seven species (*R. arboreum* var red, *R. arboreum* var pink, *T. wallichiana*, *Q. semecarpifolia*, *M. esculenta*, *D. butyracea* and *B. utilis*) have been collected from their natural zone of occurrence and stored at -80°C . Around 30-35 samples/trees were collected per population in all the species. So far 121 populations have been sampled from Uttarakhand along with their geographical coordinates. Due to less number of samples 11 populations need to be excluded.

Table 21: Details of locations of populations of different species

Population	Location
<i>Rhododendron arboreum</i> var red	
RA01	Kanchula Kharg, Chamoli, Uttarakhand
RA02	Chopta, Chamoli, Uttarakhand
RA03	Janglat Chowki, Chakrata, Dehradun, Uttarakhand
RA04	Budher, Chakrata, Dehradun, Uttarakhand
RA05	Near Nagthala, Churani, Chakrata, Dehradun, Uttarakhand
RA06	Mohankhal, Nagnath, Kedarnath, Chamoli, Uttarakhand
RA07	Kedarnath, Chamoli, Uttarakhand
RA08*	Dhanpur range, Kedarnath, Chamoli, Uttarakhand

RA09	Chinapani, Champawat, Uttarakhand
RA10	Siutal, Champawat, Uttarakhand
RA11*	Kamlake, Berinag, Pithauragarh, Uttarakhand
RA12	Devdhula, Didihaat, Pithauragarh, Uttarakhand
RA13	Raditop, Ranwai, Uttarkashi, Uttarakhand
RA14	Chaurangi Khal, Uttarkashi, Uttarakhand
RA15	Dudatoli, Pauri, Uttarakhand
RA16	Peethsen, Pauri, Uttarakhand
RA17	Chaurikhal, Chaurikhal, Uttarakhand
RA18	Adwani, Pauri, Uttarakhand
RA19	Dunagiri, Almora, Uttarakhand
RA20	Binsar, Almora, Uttarakhand
RA21	Chirbatiya, bhilangana, Tehri, Uttarakhand
RA22	Badanital, North Jhakoli, Tehri, Uttarakhand
RA23	Chandrabadni, Narendra Nagar, Tehri, Uttarakhand
RA24	Munsiyari, Khaliya top, Pithauragarh, Uttarakhand
RA25	Dhanaulti, Tehri, Uttarakhand
RA26	Gheas, Badrinath, Chamoli, Uttarakhand
RA27	Gawaldam, Badrinath, Chamoli, Uttarakhand
RA28	Mudhal, Tiuni, Dehradun
RA-29*	Motodhar, Dehradun
RA-30	Nag Tibba, Tehri
RA-31	Kosi, Kunjakhark, Nainital
<i>Rhododendron arboreum var pink</i>	
RP01	Kanchula Kharg, Chamoli, Uttarakhand
RP02	Chopta, Chamoli, Uttarakhand
RP03	Anusuya devi temple, Hans bugyal, Chamoli, Uttarakhand
RP04	Auli, Joshimath, Chamoli, Uttarakhand
<i>Taxus wallichiana</i>	
TB01*	Kanchula Kharg, Chamoli, Uttarakhand
TB02	Chopta, Chamoli, Uttarakhand
TB03	Devban, Chakrata, Dehradun, Uttarakhand
TB04	Bhujkoti, Chakrata, Dehradun, Uttarakhand
TB05	Anusuya devi temple, Hans bugyal, Chamoli, Uttarakhand
TB06	Auli, Joshimath, Chamoli
TB07	Harshil, Cholmi, Uttarkashi, Uttarakhand
TB08	Sukhitop, Uttarkashi, Uttarakhand
TB09	Bhukkitop, Uttarkashi, Uttarakhand
TB10	Dudatoli, Pauri, Uttarakhand
TB11	Gheas, Badrinath, Chamoli, Uttarakhand
TB12	Mudhal, Tiuni, Dehradun
TB13	Motodhar, Dehradun
TB14	Yamunotri, Uttarakhand
TB15	Balganga, Prinwas, Tehri
TB16	Karandam Mugyar, Naraina, Pithauragarh, Uttarakhand
TB17	Ghangharia, Chamoli, Uttarakhand
TB18	Pindari, Bageshwar
TB19	Mornaula, Nainital, Uttarakhand
TB20	Har ki Dun, Uttarakhand
TB21	Triyugi narayan, Rudraprayag, Uttarakhand
TB22	Dharma Valley, Pithoragarh, Uttarakhand
<i>Quercus semecarpifolia</i>	
QS01	Kanchula Kharg, Chamoli, Uttarakhand
QS02	Chopta, Chamoli, Uttarakhand
QS03	Devban, Chakrata, Dehradun, Uttarakhand
QS04	Bhujkoti, Chakrata, Dehradun, Uttarakhand
QS05	Lokhandi, Chakrata, Dehradun, Uttarakhand

QS06	Anusuya devi temple, Hans bugyal, Chamoli, Uttarakhand
QS07	Auli, Joshimath, Chamoli, Uttarakhand
QS08	Yamunotri, Uttarkashi, Uttarakhand
QS09	Raditop, Uttarkashi, Uttarakhand
QS10	Chaurangi Khal, Uttarkashi, Uttarakhand
QS11	Bhukkitop, Uttarkashi, Uttarkhand
QS12	Dudatoli, Pauri, Uttarkhand
QS13	Nainapeek, Uttarakhand
QS14	Badanital, North Jhakoli, Tehir, Uttarakhand
QS15*	Bamni village, Badrinath, Chamoli, Uttarakhand
QS16	Munsiyari, Khaliya top, Pithauragarh, Uttarakhand
QS17	Chaurikhal, Pauri, Uttarakhand
QS18	Gheas, Badrinath, Chamoli, Uttarakhand
QS19	Mudhal, Tiuni, Dehradun
QS20	Motodhar, Dehradun
QS21	Nag Tibba, Tehri
QS22	Balganga, Prinwas, Tehri
QS23	Kunjakhark, Nainital, Uttarakhand
QS24	Naraina ashram, Pithauragarh, Uttarakhand
QS25	Karandam Mugyar, Gudgudiya, Pithauragarh, Uttarakhand
<i>Betula utilis</i>	
BU01	Anusuya devi temple, Hans bugyal, Chamoli, Uttarakhand
BU02*	Harshil, Cholmi, Uttarkashi, Uttarakhand
BU03	Neeti, Chamoli, Uttarakhand
BU04	Bamni village, Badrinath, Chamoli, Uttarakhand
BU05	Munsiyari, Khaliya top, Pithauragarh, Uttarakhand
BU06	Karandam Mugyar, Gudgudiya, Pithauragarh, Uttarakhand
BU07	Hemkund Sahib, Valley of flowers, Chamoli, Uttarakhand
BU08	Pindari, Bageshwar
BU09	Harki Dun, Uttarakhand
BU10	Triyugi narayan, Rudraprayag, Uttarakhand
BU11	Dharma Valley, Pithoragarh, Uttarakhand
<i>Myrica esculenta</i>	
ME01	Anusuya devi temple, Hans bugyal, Chamoli, Uttarakhand
ME02	Gairsain, Kedarnath, Uttarakhand
ME03	Nagnath, Kedarnath, Chamoli, Uttarakhand
ME04	Dhanpur range, Kedarnath, Chamoli, Uttarakhand
ME05	Chinapani, Champawat, Uttarakhand
ME06	Siutal, Champawat, Uttarakhand
ME07	Kamlake, Berinag, Pithauragarh, Uttarakhand
ME08	Devdhula, Didihaat, Pithauragarh, Uttarakhand
ME09	Peethsen, Pauri, Uttarakhand
ME10	Pabo bazaar 2, Khirsu, Pauri, Uttarakhand
ME11	Adwani, Pauri, Uttarakhand
ME12	Ranikhet, Almora Uttarakhand
ME13	Dunagiri, Almora, Uttarakhand
ME14	Kosani, Bageshwar, Uttarakhand
ME15	Takula, Almora, Uttarakhand
ME16	Seetalakhet, Almora, Uttarakhand
ME17	Bhawali, Nainital, Uttarakhand
ME18	Mayali forest, Jhakoli range, Rudraprayag, Uttarakhand
ME19*	Hulanakhal forest, Bhilangana, Tehri, Uttarakhand
ME20	Chandrabadni temple, Narendra nagar, Tehri, Uttarakhand
ME21*	Munsiyari, Khaliya top, Pithauragarh, Uttarakhand
ME22	Lancedon, Pauri, Uttarakhand
ME23*	Dhanaulti, Tehri, Uttarakhand
ME24	Gawaldam, Badrinath, Chamoli, Uttarakhand

ME25*	Shaiya, Chakrata
ME26	Jageshwar, Uttarakhand
ME27	Devidhura, Champawat, Uttarakhand
<i>Diploknema butyracea</i>	
DB01*	Lohaghat, Champawat, Singda, Uttarakhand

*Populations not to be included because of less number of samples

2. Extraction of Genomic DNA:

Genomic DNA has been extracted from all the populations in all species. Genomic DNA was quantified for its purity and concentration. PCR protocols were standardized for all the species.

3. SSR screening in different species:

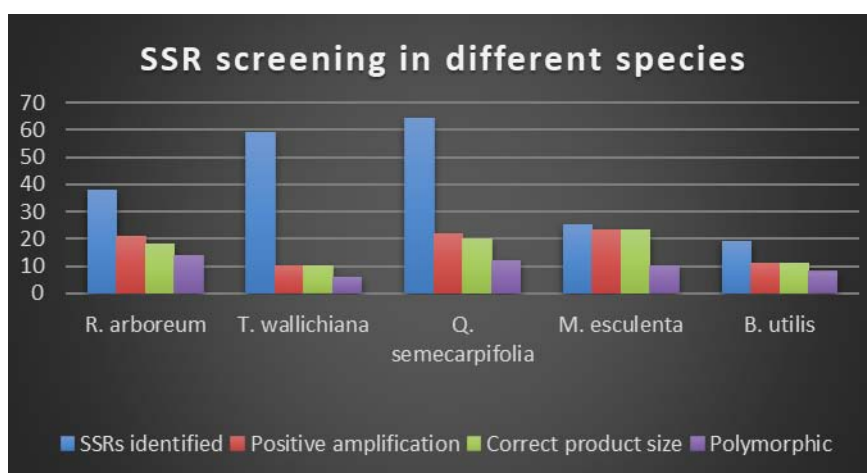


Figure 9: Cross-species amplification of SSRs in different species

4. Validation of SSR markers in different species:

The polymorphic SSRs were further validated for the presence of repeat motifs in the selected species through sequencing of the PCR product. 10 SSRs each have been validated in *R. arboreum*, *T. wallichiana*, *M. esculenta* and *Q. semecarpifolia* while 17 SSRs were validated in *B. utilis*.

5. Genotyping using validated SSR markers:

The validated SSRs were used for genotyping of all the populations in different species. Details of the progress of genotyping work are given in the table below:

Table 22: Genotyping status in different species

Species	SSRs validated	Total Populations	Genotyping status	
			Populations	Primers
<i>R. arboreum</i>	10	27	27	10
<i>Q. semecarpifolia</i>	10	24	24	10
<i>T. wallichiana</i>	10	21	21	10
<i>B. utilis</i>	10+7	9	9	17
<i>M. esculenta</i>	10	23	23	10

Genotyping work has been completed in *R. arboreum* along with data compilation. Genotyping of missing data of *R. arboreum* is still in progress. Manuscript for *Q. semecarpifolia* that was submitted is under review.

6. **Allelic pattern and gene diversity across populations:**
The allele pattern including number of different alleles, allele frequency among the populations, number of private alleles (alleles unique to a single population) and expected heterozygosity was calculated for all species.
7. **Genetic differentiation and AMOVA analysis:**
Molecular variation was estimated by AMOVA analysis using the software GenAlEx 6.5. Partitioning of molecular variance was done first assuming no hierarchical structure and then hierarchical structuring was done assuming two levels i.e. among populations and within populations according to the higher level clusters computed in the dendrogram.
8. **Genetic structure analysis of populations**
Bayesian clustering method was used to elucidate the genetic structure among populations using the software STRUCTURE ver 2.2. Population genetic structure analysis revealed the presence of 2 subpopulations in *Q. semecarpifolia* indicating the presence of admixed ancestry.
9. **Genetic relatedness using Cluster analysis:**
The genetic relationship among different populations of *Q. semecarpifolia*, *T. wallichiana* and *M. esculenta* was analyzed through cluster analysis based on Nei's genetic distance using the software POPTREE ver.2.
10. **Spatial representation of inrapopulation genetic diversity:**
Expected heterozygosity, allelic richness, private allelic richness, total no. of alleles and Shannon's diversity index were interpolated using the IDW function to understand the geographical distribution of genetic diversity of *Q. semecarpifolia*, *M. esculenta* and *T. wallichiana* in Uttarakhand region. This would help in identification of regions with high level of genetic diversity and private alleles which are most suitable for conservation.

b. DISEASE SURVEY

Sample collection:

The details of the location and month of collection of different species are given in the table below:

Table 23: Details of location and month of collection of samples

Month	Location	Species
June, 2016	Gopeshwar and Chakrata	<i>R. arboreum</i> , <i>B. utilis</i> , <i>T. wallichiana</i> and <i>Q. semecarpifolia</i>
April, 2017	Uttarkashi	<i>R. arboretum</i> , <i>T. wallichiana</i>
Sep, 2017	Munshyari, Pithauragarh	<i>R. arboreum</i> , <i>M. esculenta</i> , <i>B. utilis</i> and <i>Q. semecarpifolia</i>
Jan, 2018	Almora, Nainital, Rudraprayag, Tehri, Chamoli and Srinagar, Uttarakhand.	<i>R. arboreum</i> , <i>M. esculenta</i> , <i>B. utilis</i> , <i>T. wallichiana</i> and <i>Q. semecarpifolia</i>
March, 2018	Nain Bagh, Nain Tippa	<i>R. arboreum</i> , <i>Q. semecarpifolia</i> and <i>T. wallichiana</i>

May, 2018	Jageshwar, Almora and Kunjajhar, Nainital	<i>M. esculanta</i> , <i>R. arboreum</i> and <i>Q. semecarpifolia</i>
July, 2018	Karandam mugyar, Dharchula	<i>B. utilis</i> , <i>T. wallichiana</i> and <i>Q. semecarpifolia</i>
Aug, 2018	Valley of flowers, Chamoli, Uttarakhand	<i>B. utilis</i> , <i>T. wallichiana</i>
Sept, 2018	Pindari, Bageshwar	<i>B. utilis</i> , <i>T. wallichiana</i>
April, 2019	Chopta, Tungnath temple premises and Trijugi Narayan temple	<i>R. arboreum</i> , <i>R. barbatum</i> (RB) and <i>R. campanulatum</i>
May, 2019	Har ki Doon	<i>B. utilis</i> and <i>T. wallichiana</i>

Isolation and identification of pathogens:

Disease samples of different tree species from different locations were brought to the Forest Pathology Laboratory. Samples were cut with surgical blade containing 50% diseased and 50% healthy tissues and surface sterilized with 0.1% Sodium hypochlorite or 70% ethanol solution. It was then placed in sterile PDA petriplates. Culture plates were then allowed to incubate at 25-28°C in BOD incubator for 3-5 days or more. Fungal organism attained growth on media. Then, it was identified under Phase Contrast Microscope with the help of texts, monographs and available expertise in the division.

Table 24: Details of the disease symptoms and causal fungal species isolated

Sample	Disease symptoms	Causal fungal species
<i>Rhododendron arboreum</i>		
RA- 5.3	Leaf spot	<i>Phyllosticta</i> sp.
RA- 5.7	Leaf blight	<i>Alternaria fasciculata</i>
RA-5.9	Leaf blight	<i>Alternaria alternata</i>
RA-5.12	Leaf spot	<i>Chaetomium globosum</i>
RA-5.30	Bud blight	<i>Pithomyces</i> sp.
RA-21.2	Greyish spots on leaf surface	<i>Curvularia</i> sp.
RA-21.2	Blight of base of leaf	<i>Gliocladium</i> sp.
RA-21.7	Lesions on mid rib of leaf	<i>Graphium</i> sp.
RA-21.8	Leaf tip blight with white patches	<i>Blastomyces</i> sp.
RA- 24.2	Leaf spot	<i>Curvularia</i> sp.
RA-24.6	Leaf blight	<i>Fusarium</i> sp.
RA-25.1	Leaf gallon upper and lower surface	<i>Exobasidium vaccinii</i>
RA-25.18	Leaf blight	<i>Alternaria alternata</i>
RA-25.22	Leaf spot and necrosis in the leaf area	<i>Sordaria fimicola</i>
RA-25.22	Leaf spot and leaf tip blight	<i>Nigrospora sphaerica</i>
RA-25.25	Leaf spot and yellowing in the spot areas	<i>Chaetomium</i> sp.
RA-25.27	Leaf spot and margins were blighted	<i>Alternaria</i> sp.
RA-25.30	Leaf spot	<i>Cladosporium herbarum</i>
RA-28.12	Leaf tip blight covering laminar region	<i>Alternaria phragmospora</i>
RA-28.13	Leaf spots and marginal blight	<i>Fusarium oxysporum</i>
RA-28.16	Greyish leaf spots	<i>Curvularia</i> sp.
RA-28.25	Light brown necrotic leaf spots	<i>Aspergillus niger</i>
RA-29.1	Leaf blotch and brownish spots covering leaf	<i>Hansfordia</i> sp.
RA-29.7	Leaf spots	<i>Cladosporium</i> sp.
RA-29.10	Blight on base of leaf covering entire lamina	<i>Aureobasidium</i> sp.
RA-31.14	Black spots on entire leaf surface	<i>Cladosporium</i> sp.
RA-31.20	Browning of mid rib with black spots on leaf	<i>Phomopsis</i> sp.
Diseased samples (RA) collected from Munch, Champawat Forest Division, 2019		
RA 1	Leaf tip blight	<i>Alternaria</i> sp.
RA 3	Leaf tip blight	<i>Pestalotiopsis</i> sp.
RA 4	Leaf blight	<i>Alternaria</i> sp.

RA 5	Leaf tip blight	<i>Penicillium</i> sp.
Diseased samples (RA) collected from Chirapani, Champawat Forest Division, 2019		
RA 1	Leaf spot	<i>Curvularia</i> sp.
RA 2	Leaf tip blight	<i>Pestalotiopsis</i> sp.
Diseased samples (ME) collected from Champawat Forest Division, 2019		
ME 1	Leaf spot	<i>Alternaria</i> sp.
ME 2	Leaf spot	<i>Fusarium</i> sp.
ME 3	Leaf spot	<i>Phomopsis</i> sp.
<i>Quercus semecarpifolia</i>		
QS- 3.6	Root and butt rot	<i>Ganoderma lucidum</i>
QS- 6.10	Heart rot	<i>Spongipellis unicolor</i>
QS- 16.2	Leaf spot	<i>Curvularia</i> sp.
QS- 16.7	Leaf blight	<i>Alternaria alternata</i>
QS-17.01	Leaf stain and spots	<i>Verticillium</i> sp.
QS-17.13	Leaf spot with greyish brown halos	<i>Nigrospora sphaerica</i>
QS-17.16	Leaf spot	<i>Phomopsis</i>
QS-17.21	Leaf spot and necrosis	<i>Fusarium</i> sp.
QS-17.23	Leaf tip and marginal blight	<i>Hemicola</i> sp.
QS-17.25	Leaf spot	<i>Cladosporium</i> sp.
QS-17.27	Leaf spots covering the entire lamina	<i>Alternaria</i> sp.
QS-18.21	Leaf blotch	<i>Cladosporium sphaerospermum</i>
QS-18.29	Leaf tip blight and spots	<i>Alternaria alternata</i>
QS-20.01	Leaf necrosis and blackish spots	<i>Alternaria</i> sp.
QS-20.04	Black lesions on upper surface of leaves	<i>Nigrospora</i> sp.
QS-20.04	Black spots on leaf surface	<i>Phomopsis</i> sp.
QS-20.06	Leaf blight	<i>Graphium</i> sp.
QS-20.12	White spot on leaves	<i>Verticillium</i> sp.
QS-20.15	Dark lesions and blight on upper surface of leaf	<i>Cladosporium</i> sp.
QS-20.16	Brownish spots covering the entire lamina	<i>Hymenula</i> sp.
QS-22.10	Black spots on upper leaf surface	<i>Macrophomina</i> sp.
QS-22.11	Blackening of mid rib and blight	<i>Cladosporium</i> sp.
QS-23.06	Powdery spots on leaf surface	<i>Acremonium</i> sp.
QS-23.10	Brown spots on leaf surface	<i>Alternaria</i> sp.
QS-23.13	Leaf margins was blighted	<i>Fusarium</i> sp.
QS-24.02	Leaf blight	<i>Alternaria phragmospora</i>
QS-24.03	Leaf spots	<i>Alternaria</i> sp.
QS-24.03	Brown spots and blight on leaf	<i>Curvularia</i> sp.
QS-24.05	Leaf blight	<i>Cladosporium cladosporoides</i>
QS-24.06	Black powdery mass on leaf	<i>Penicillium chrysogenum</i>
QS-24.08	Leaf spot	<i>Pestalotiopsis</i> sp.
QS-24.10	Powdery growth on leaf	<i>Aspergillus flavus</i>
QS-24.15	Leaf spot	<i>Curvularia lunata</i>
QS-25.02	Leaf tip blight	<i>Not identified</i>
QS-25.03	Leaf sooty mold	<i>Aspergillus nidulans</i>
QS-25.06	Leaf blight	<i>Phytophthora</i> sp.
QS-25.12	Leaf spot	<i>Alternaria chlamydozpora</i>
QS-25.14	Leaf margin blight	<i>Cladosporium herbarum</i>
QS-25.22	Leaf spot	<i>Rhizopus</i> sp.
<i>Taxus wallichiana</i>		
TW- 3.14	Leaf spot	<i>Cladosporium</i> sp.
TW- 3.22	Leaf blight	<i>Cunninghamella</i> sp.
TW-11.05	Leaf twig rot	<i>Macrophomina</i> sp.
TW-11.08	Leaf spot and lesions on the lower surface	<i>Cladosporium herbarum</i>
TW-11.09	Leaf spot and white mycelial growth in twig	<i>Aspergillus niger</i>
TW-11.10	Leaf spot	<i>Alternaria</i> sp.

TW-11.14	Leaf spots and blight	<i>Aspergillus flavus</i>
TW-11.20	Leaf and twig spots	<i>Cladosporium cladosporoides</i>
TW-11.20	Black spots on lower surface of leaves	<i>Nigrospora</i> sp.
TW-11.21	Leaves were blighted	<i>Graphium</i> sp.
TW-11.26	Leaf blight and spots on petiole	<i>Penicillium chrysogenum</i>
TW-12.10	Black spots on lower surface of leaves	<i>Alternaria</i> sp.
TW-12.10	Rotting of leaves	<i>Fusarium</i> sp.
TW-12.14	Brown spots on margins of leaves	<i>Alternaria chlamydospora</i>
TW-12.20	Leaf spots on upper and lower surface	<i>Nigrospora</i> sp.
TW-12.22	Greyish black lesions on lower surface of leaves	<i>Curvularia</i> sp.
TW-12.23	Leaf tip blight	<i>Fusarium</i> sp.
TW-14.04	Leaf spots on lower leaves	<i>Bipolaris</i> sp.
TW-14.06	Leaves on top were blighted	<i>Alternaria</i> sp.
TW-14.10	Greyish spots on lower surface of leaves	<i>Curvularia</i> sp.
TW-14.11	Browning of twig and leaves	<i>Gliocladium</i> sp.
TW-14.13	Damping off of new leaves	<i>Sporobolomyces</i> sp.
TW-14.19	Browning of twigs and leaf petioles	<i>Paecilomyces</i> sp.
TW-15.05	Yellowing of leaves with brown spots	<i>Blastomyces</i> sp.
TW-16.01	Leaf spot	<i>Alternaria chlamydospora</i>
TW 16.05	Leaf blight	<i>Cladosporium herbarum</i>
TW 16.12	Leaf spot	<i>Nigrospora</i> sp.
TW 16.13	Leaf tip blight	<i>Fusarium semitectum</i>
TW 17.02	Leaf spot	<i>Pestalotiopsis</i> sp.
TW 17.04	Leaf browning	<i>Penicillium chrysogenum</i>
TW 17.06	Twig blight	<i>Monilinia</i> sp.
TW 17.09	Leaf blight	<i>Alternaria</i> sp.
TW 17.12	Black spots on leaf	<i>Phomopsis</i> sp.
TW 17.14	Leaf tip blight	<i>Fusarium</i> sp.
TW 18.01	Leaf blight	<i>Plectosphaerella</i> sp.
TW 18.04	Black spots on leaf	<i>Nigrospora</i> sp.
TW 18.06	Leaf spot	<i>Alternaria brassicola</i>
TW 18.08	Leaf blight	<i>Fusarium</i> sp.
TW 18.09	Leaf blight	<i>Cladosporium herbarum</i>
TW 18.13	Leaf spot	<i>Curvularia pallescens</i>
TW 18.16	Grey spots on leaf	<i>Curvularia</i> sp.
TW 18.17	Leaf spot	<i>Phomopsis</i> sp.
TW 18.20	Leaf spot	<i>Nigrospora</i> sp.
TW 18.22	Leaf tip blight	<i>Cladosporium cladosporoides</i>
TW-20.02	Leaf blight	<i>Gliocladium</i> sp.
TW-20.16	Leaf spot	<i>Arthrimum</i> sp.
<i>Myrica esculenta</i>		
ME-21.5	Leaf rust	<i>Puccinia</i> sp.
ME-21.9	Leaf gall	<i>Aphid suspected</i> (Insect)
ME-21.13	Leaf blotch	<i>Alternaria fasciculata</i>
ME-26.10	Brown leaf spots	<i>Alternaria</i> sp.
ME-26.13	Greyish leaf spot	<i>Curvularia</i> sp.
ME-26.13	Black spots on entire lamina of leaf	<i>Nigrospora</i> sp.
ME-26.20	Leaf blight	<i>Fusarium</i> sp.
<i>Betula utilis</i>		
BU-1.5	Leaf blight	<i>Lacellina</i> sp.
BU-5.4	Leaf blight	<i>Alternaria triticina</i>
BU-5.11	Leaf spot	<i>Helminthosporium</i> sp.
BU-5.14	Leaf spot	<i>Alternaria chlamydospora</i>
BU-6.03	Leaf tip blight	<i>Alternaria</i> sp.
BU-6.04	White superficial growth on leaf	<i>Aspergillus niger</i>
BU-6.07	Leaf spot	<i>Alternaria alternata</i>
BU-6.08	Leaf blight	<i>Cladosporium cladosporoides</i>

BU-6.10	Leaf spot	<i>Aspergillus niger</i>
BU-6.11	Brown leaf spot	<i>Curvularia lunata</i>
BU-6.12	Leaf rust	<i>Puccinia</i> sp.
BU-6.14	Leaf blight	<i>Fusarium</i> sp.
BU-6.17	Blackening of leaf	<i>Rhizopus</i> sp.
BU-6.20	Powdery growth on leaf	<i>Fusarium</i> sp.
BU-7.03	Powdery growth on leaf	<i>Fusarium</i> sp.
BU-7.05	Leaf blight	<i>Aspergillus niger</i>
BU-7.07	Brown spots on leaf	<i>Alternaria alternata</i>
BU-7.08	Leaf spot	<i>Alternaria rosae</i>
BU-7.09	Leaf spot	<i>Pestalotiopsis</i> sp.
BU-7.11	Leaf blight	<i>Cladosporium fusiforme</i>
BU-7.13	Leaf spot	<i>Curvularia chlamydospora</i>
BU-7.15	Black spots on leaf	<i>Cladosporium</i> sp.
BU-7.16	Leaf blight	<i>Cladosporium cladosporoides</i>
BU-7.29	Leaf spot	<i>Chaetomium</i> sp.
BU-8.01	Leaf blight	<i>Cladosporium herbarum</i>
BU-8.03	Leaf spot	<i>Helminthosporium</i> Sp.
BU-8.04	Leaf blight	<i>Fusarium</i> sp.
BU-8.07	Leaf spot	<i>Alternaria alternata</i>
BU-8.22	Leaf rot	<i>Xylaria</i> sp.
BU-8.24	Leaf spot	<i>Mortierella</i> sp.
BU-8.30	Leaf rust	<i>Puccinia</i> sp.
BU-9.22	Leaf blight	<i>Alternaria</i> sp.
BU-9.23	Leaf blight	<i>Alternaria</i> sp.
BU-9.28	Leaf spot	<i>Cladosporium</i> sp.

Isolation and identification of seed mycoflora

Seeds were inoculated on autoclaved PDA medium and incubated at 25-28°C in BOD incubator for 5-7 days. Different types of fungal colonies appeared on the media. Sub culturing of the fungal culture was done after the growth on 3rd – 4th day for further purification. Pure cultures were maintained as slants at 5°C in refrigerator. Different types of fungal colonies grew on the seeds in the media which were identified under the microscope.

Table 25: Details of the fungal species isolated from different samples

Seeds (with source)	Isolated fungi
<i>Schleichera oleosa</i> (Chilla)	(a) <i>Penicillium</i> spp.
	(b) <i>Rhizopus</i> spp.
	(c) <i>Aspergillus</i> spp.
<i>Schleichera oleosa</i> (Narendranagar)	(a) <i>Mucor</i> spp.
	(b) <i>Penicillium</i> spp.
<i>Schleichera oleosa</i> (Balawala)	<i>Verticillium</i> spp.
<i>Haloptelia integrifolia</i>	(a) <i>Cylindrocephalum</i> spp.
	(b) <i>Hendersonia</i> spp.
<i>Acacia catechu</i> (Thano)	<i>Aspergillus</i> (2 species)
<i>Aegle marmelos</i> (Haldwani)	(a) <i>Rhizopus</i> spp.
	(b) <i>Aspergillus</i> (2 species)
<i>Hippophae salicifolia</i> (Yamunotri)	<i>Penicillium</i> (2 species)
<i>Albizia julibrissin</i>	(a) <i>Aspergillus</i> ,
	(b) <i>Rhizoctonia</i> ,
	(c) <i>Gonatorrhodiella</i>
<i>Ougenia ogeinensis</i> (Rajaji National Park)	<i>Aspergillus</i> (2 species)
<i>Pyrus pashia</i> (Champawat)	(a) <i>Aspergillus</i>
	(b) <i>Rhizopus</i>

<i>Toona ciliata</i>	<i>Rhizopus</i>
<i>Fraxinus</i>	<i>Aspergillus</i>
<i>Dalbergia sissoo</i>	(a) <i>Alternaria</i> ,
	(b) <i>Aspergillus</i>

Preservation of fungal cultures

Mineral oil preservation technique was used to preserve important fungal pathogens. Pure fungal cultures isolated from diseased leaf samples of *Rhododendron arboreum*, *Taxus wallichiana*, *Betula utilis*, *Quercus semecarpifolia* and *Myrica esculenta* from different regions were duly subcultured in freshly prepared PDA culture tubes and left for incubation in BOD incubator at 25-28°C. On gaining maturity, autoclaved mineral/paraffin oil was added to the cultures 1'' (one inch) above the layer of agar in culture tubes. Then, fungal cultures were preserved at 5°C in repository for further experimentation purposes.

(C) CHEMICAL CHARACTERIZATION

Biochemical characterization of *R. arboreum* population lines is being carried out with respect to the **total flavonoid contents** (TFCs), in their flowers using spectrophotometric method. *M. esculenta* population lines are being characterized with respect to the **total phenolics content** (TPCs), in their stem bark using spectrophotometric method. Further stem bark samples collected from *B. utilis* were characterized with respect to **Tri-terpenoid Content** (TTCs). A brief report about the biochemical characterization of different species is given in the table below.

Table 26: Biochemical characterization performed in different species

Species	Biochemical characterization	Population	TFCs (mg rutin equivalent/g extract)
<i>Rhododendron arboreum</i>	Total Flavonoid Content	RA03	38.06 ±0.36 to 214.41± 4.04 (mean value 111.26 ±1.21)
		RA04	42.06 ±0.22 to 141.44± 1.98 (mean value 97.97 ±1.47)
		RA05	70.96 ±1.33 to 224.44 ±0.88 (mean value 128.66 ±1.35)
		RA15	50.64 ±1.11 to 69.45± 0.08 (mean value 59.74 ±6.34)
		RA17	63.84 ±0.11 to 85.17 ±0.44 (mean value 71.36±8.23)
		RA14	70.01±0.70 to 62.52±5.65 (mean value 67.76±3.51)
		RA16	61.19±0.08 to 58.94±0.61 (mean value 59.90±1.16)
		RA13	73.84±0.11 to 63.45±2.87 (mean value 67.96±5.18)
		RA19	36.97± 0.99 to 59.23±0.88 (mean value 47.45±9.12)
		RA20	58.82±2.03 to 47.76±0.1) (52.17±5.85)
Species	Biochemical characterization	Population	TPCs (mg GAE/g extract)
<i>Myrica esculenta</i>	Total Phenolic Content	ME05	411.03 ±2.34
		ME06	586.84 ±0.98
		ME07	635.81±1.36
		ME08	523.72 ±0.83
		ME9	54.94±0.56 to 70.40±4.69 (mean value 63.33±2.08)

		ME10	61.47±0.10 to 67.52±0.62 (mean value 65.30±0.26)	
		ME11	77.08 ±1.15 to 86.92±6.11 (mean value, 82.76±2.52)	
		ME12	55.41±0.41 to 88.29±7.26 (mean value 70.88±15.67)	
		ME13	76.70±0.88 to 82.08±5.89 (mean value 79.13±2.72)	
		ME14	74.30±0.72 to 77.51±4.32 (mean value, 76.24±1.70)	
		ME15	63.13±0.46 to 69.03±0/36 (mean value 66.35±1.94)	
		ME16	62.25±0.15 to 84.77±0.41 (mean value 75.89±0.13)	
		ME17	59.85 ±0.04 to 75.66±0.57 (mean value, 69.06±0.22)	
		ME18	61.77 ±0.10 to 72.94±0.57 (mean value, 66.64±0.28)	
		ME22	38.35 ±0.04 to 46.61±0.36 (mean value, 42.47±0.13)	
		ME23	46.87 ±0.06 to 53.64±0.17 (mean value, 50.25±0.28)	
	Carbohydrate content of fruit juice		735.48 mg glucose equivalent per gm of juice	
	Protien content of fruit juice		31.18 mg BSA equivalent per 100gm of juice	
	Ash content of fruit juice		2.72%	
	Crude fat content of fruit juice		0.01%	
Species	Biochemical characterization	Population	TTCs	
<i>Betula utilis</i>	Tri-terpenoid Content	BU01	1642±166.87 to 1082±36.76 (mean value 1305±229.6)	
		BU02	2388 ±220.617 to 1828 ±22.62 (mean value 2057 ±257.06)	
		BU03	2622 ±25.45 to 3282±138.59 (mean value 2996±250.91)	
		BU04	1816 ±48.08 to 2290±96.16 (mean value 2137±217.11)	
		BU05	740 ±22.62 to 1192±93.33 (mean value 1072±341.35)	
		BU08	4.58±0.01 to 4.89±0.08 (mean value 4.71±0.03)	
		BU06	5.74 ± 0.02 to 6.34 ± 0.34 (mean value 5.98 ± 0.29)	
		BU10	(2.83±0.02 to 2.93±0.07 (mean value 2.87±0.02)	
		BU11	(4.38±0.01 to 6.26±0.09 (mean value 5.57±0.03)	
		Betulin, Betulinic acid, lupeol and oleanolic acid assisted characterization	5 populations	Betulin was detected in 5 population BU-01 to BU-05
		HPLC analysis for the marker betulin (µg / g)	BU06	12.10
BU07	20.49			
BU08	11.96			
BU11	6.19			
	Bark was lyophilized and milled for isolation of their extractives	BU08, BU10	Done	
	Methanol extract reisolated	BU01-BU05	-	

	from bark for HPLC analysis		
	Needles were lyophilized and milled for isolation of their extractives	3 populations	-
Species	Biochemical characterization	Population	Chemical analysis
<i>Quercus semecarpifolia</i>	Total Phenolic Content	QS01	39.14±0.37 to 46.34±4.15 (mean value 42.05±3.33)
		QS02	42.79±0.09 to 50.09±4.84 (mean value 47.97±2.077)
		QS03	38.28±0.09 to 40.91 ±0.15 (mean value, 39.40±0.15)
		QS05	31.22 ± 0.18 to 31.71 ±0.03 (mean value 31.51 ± 0.06)
		QS06	39.82 ± 0.03 to 42.57 ±2.96 (mean value 40.75 ± 1.44)
		QS08	98.15±0.44 to 99.92±0.68 (mean value 99.06±0.41)
		QS09	101.96±0.18 to 102.31±0.74 (mean value 102.09±0.25)
		QS10	53.86 ±0.12 to 60.45±0.31 (mean value, 55.85±0.08)
		QS11	72.93 ±0.06 to 83.28±2.94 (mean value, 77.87±1.43)
		QS13	81.11 ±0.37 to 82.93±0.94 (mean value, 82.04±0.29)
		QS17	41.12±0.25 to 42.62±1.56 (mean value, 42.02±0.83)
		QS19	17.01±0.06 to 18.59±1.87 (mean value 17.94±1.02)
		QS20	81.46±0.84 to 94.23±4.56 (mean value 88.24±1.97)
		QS21	43.03 ±0.06 to 43.69±0.09 (mean value, 43.40±0.01)
QS23	30.04 ±0.06 to 31.92±0.34 (mean value, 30.91±0.12)		
<i>Taxus wallichiana</i>	Leaves are lyophilized and milled	TB05-TB15	done
	Methanol extract isolated for marker assisted chemical screening	TB05, TB09 and TB-11	-
	10–Deacetylbaocatin-III (10DAB-III) content (µg / g)	TB03	387.31
		TB05	284.20
		TB06	160.60
		TB09	151.88
		TB11	393.04
		TB15	136.25
		TB18	75.15
		TB22	61.98

	Needles were lyophilized, milled and extracted with methanol. The extracts were purified using column chromatography for their 10-Deacetylbaccatin-III assisted chemical screening. HPLC assisted chemical screening of the purified extracts led to identify and quantify 10-DAB-III in all the populations.	TB02, TB10, TB12, TB13, TB14, TB19, TB21	
Species	Biochemical characterization	Population	Chemical analysis
<i>Diploknemabut yracea</i>	Leaves are lyophilized, milled and stored	DB01	-

Principal Component Analysis:

RA-03 and RA-05 were identified as chemically superior populations. In *B. utilis*, clustering of populations was not observed. However, BU-03 containing maximum TTC (2996 mg UAE per gm of extract) was found to be chemically superior among all the five populations examined.

B. FGR conservation

Six priority species *Cinnamomum tamala*, *D. butyracea*, *R. arboreum*, *M. esculanta*, *T. wallichiana* and *Toona ciliata* have been short listed for FGR conservation. The survey and review of literature was conducted to know distribution and status of prioritized species. Different forest areas were visited for exploring the possibility of field gene banks.

Development of nursery techniques for priority FGR species

Nursery techniques have been standardized for *Diploknema butyracea*, *Cinnamomum tamala*, *Taxus baccata* and *Rhododendron arboreum*. Experiments are in progress for *Myrica esculenta*.

Establishment of field gene banks of prioritized species

Germplasm of six prioritised species i.e. *Diploknema butyracea*, *Rhododendron arboreum*, *Myrica esculenta*, *Cinnamomum tamala*, *Taxus walichiana* and *Toona ciliata* collected from different populations and propagated in the nursery for the establishment of field gene banks. The sites were identified for establishment of field gene banks in land provided by Uttarakhand Forest Department. Field work on fencing and pit digging was carried out.

Field gene banks of six prioritised species i.e. *Diploknema butyracea*, *Rhododendron arboreum*, *Myrica esculenta*, *Cinnamomum tamala*, *Taxus walichiana* and *Toona ciliata* have been established in different forest Divisions of Uttarakhand. The field gene bank of each species have been established in 0.5 ha area. The area of each gene banks protected well before plantation either by chain link fencing or barbed fencing as per requirement, protected from wild and domestic animals. Details of the gene bank are given in table 28.

Table 27: Details of the gene banks established in different forest divisions of Uttarakhand

S. No.	Species	Location	Geo-Coordinates	Seed source planted
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1.	<i>Diploknemma butyracea</i>	Kali Kumayoun Ranage, Chanpawat Forest Division, Uttarakhand	N29°29'40.4" E080°05'49.8" Alt.:1098m	1. Champawat 2. Pithoragarh 3. FRI Dehradun 4. Almora
2.	<i>Rhododendron arboreum</i>	Devidhura forest range, Chanpawat Forest Division, Uttarakhand	N29°26'50.3" E079°46'57.0" Alt: 2161m	1. Pauri 2. Tehri 3. Uttarkashi 4. Chakrata (Kalsi)
3.	<i>Myrica esculenta</i>	Bhowali Forest Range, Nainital Forest Division, Uttarakhand	N 29°23'25.1" E079°27'40.7" Alt: 1564m	1. Pithauragarh 2. Champawat 3. Pauri
4.	<i>Cinnamomum tamala</i>	Nalena-II Forest Range, Nainital Forest Division, Uttarakhand	N 29°21'27.0" E079°27'25.1" Alt: 1700m	1. Nainital 2. Pauri 3. Pithauragarh 4. Tehri
5.	<i>Taxus wallichiana</i>	Malari Beat, Joshimath Forest Range, Nanda Devi National Park Forest Division, Uttarakhand	N30°40'42.1" E079°53'42.6" Alt. 3230m	1. Chakrata, (Kalsi) 2. Chamoli, 3. Uttarkashi, 4. Auli
6.	<i>Toona ciliata</i>	Village Maikhura, District- Chamoli (Nandprayag Forest Range, Badrinath Forest Division)	-	23 genotypes

The team has recently visited the field gene banks of five prioritised species i.e. *Diploknema butyracea*, *Rhododendron arboreum*, *Myrica esculenta*, *Cinnamomum tamala*, and *Toona ciliata* and fixed permanent display boards of technical content at all sites except for *Taxus wallichiana* which is situated at a very high altitude (3230 m) in Joshimath Forest Range, Nanda Devi National Park Forest Division, Uttarakhand. Germplasm conserved in the field gene banks are growing very well.

***Circa situm* conservation of remnant individuals of important FGRs**

- The role of *circa situm* (farmer based conservation) approaches is important in conserving tree species which are typically found in private land. These approaches have been used to distinguish the very different circumstances of conservation within altered agricultural landscapes outside natural habitats but within a species native geographical range.
- Survey has been carried out for *Diploknema butyracea* and remnant trees have been located in six villages in two districts viz. Champawat and Pithoragarh. Studies for conservation status are in progress. Initial observations indicate that the mature trees of remnant populations are conserved by local people. The information is summarized in the following Table.

Table 28: *Circa situm* conservation status of *Diploknemma butyracea*

Species/ Family	Location (district)	Range/Village (ghat range)	Family	Seed collection Time
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<i>Diploknema butyracea</i> (Sapotaceae)	Pithoragarh	Jhadapani 841.3m N 29°29'47.1'' E 80°09'04.6''	15 Families (40 plants) 3 trees per family	July
		Dakuda 878.6m N 29°23'51.4'' E 80°05'03.7''	20 Families (35 plants) 2 trees per family	June-july
		Gurna 842.2m N 29°29'47.0'' E 80°09'04.5''	12 Families (50 plants) 4 trees per family	July-August
		Shinghda 881.3m N 29°23'56.1'' E 80°05'09.9''	14 Families (20plants) 1 tree per family	July

- Survey has been carried out for *Cinnamomum tamala* and remnant trees have been located in five villages in two districts viz. Nainital and Almora. Studies for conservation status are in progress. Initial observations indicate that the mature trees of remnant populations are conserved by local people. The information is summarized in the following Table.

Table 29: Circa situm conservation status of *Cinnamomum tamala*

Location (district)	Range/Village(ghat range)	Family	Seed collection Time
Nainital	Chopra village 990m N 29°19'514'' E 79°29'943''	300 Families (15000 plants) 50-60 trees per family	December
	Dogaon village 917m N 29°23'51.4'' E 80°05'03.7''	5 Families (20 plants) 4 trees per family	December
Almora	Harda village 1186m N 29°37'095'' E 79°11'715''	100 Families (500 plants) 5 trees per family	December
	Baudtalla village 1005m N 29°37'095'' E 79°11'425''	100 Families (700 plants) 7 tree per family	December
	Baudmalla village 1001m N 29°37'095'' E 79°11'425''	90 Families (900 plants) 10 tree per family	December

Establishment of FGR Conservation Areas (FGR-CAs) in natural forests for species of high conservation concern

For establishment of FGR Conservation areas, seven populations of *D. butyracea* have been located in Distt Pithoragarh at altitudinal range of 780 to 1290 m., eleven sites for *Taxus wallichiana*, sixteen for *Myrica esculenta*, twenty-two for *R. arboreum* var. Red and three for *R. arboreum* var. Pink have been located.

