Nurturing rich and beautiful forests for the future generation

Forestry and Forest Products Research Institute

National Research and Development Agency
Forest Research and Management Organization

Forestry and Forest Products Research Institute
Forest Tree Breeding Center
Forest Bio-Research Center

Professionals in forest and development


Plus-tree Saeki No. 3

Forest Tree Breeding Center (FTBC) and Forest Bio-Research Center (FBRC), both have been engaged in forest tree breeding by development of genetically superior varieties, speed-up breeding process through high-tech application, collection and conservation/preservation of genetic materials, and international technical cooperation on forest tree breeding.

Features

【The largest institute of forest tree breeding in Japan】

- FTBC, the largest center of forest tree breeding in Japan, has developed more than 2,400 new genetically superior varieties of forest tree species.
- FTBC is also serving as a core organization for the distribution of new varieties of clones to the prefectural government seed/scion orchards which are functioning as the authorized regional seed/scion supply centers for private nurseries.
- There are 5 Breeding Regions in Japan. Breeding regions are set up considering climate conditions, tree species and administration areas of the national forest and prefectural governments.
- FBRC has conducted studies to develop the techniques necessary for shortening breeding periods of forest trees by using biotechnologies.
- As one of the world's prime research institute in forest tree breeding, FTBC is leading in the research and development of pine wilt nematode resistant varieties and pollen free/ less pollen varieties, and snow damage tolerant varieties, which other countries have not developed yet.
- FTBC is carrying out its R/D (Research and Development) taking due consideration of regional climate differences and associated species diversity with four regional breeding offices, i.e.Hokkaido,Tohoku,Kansai and Kyushu, also Iriomote tropical forest tree breeding garden where tropical and sub-tropical forest tree species are main targeted species.

【The only forest tree gene bank in Japan】

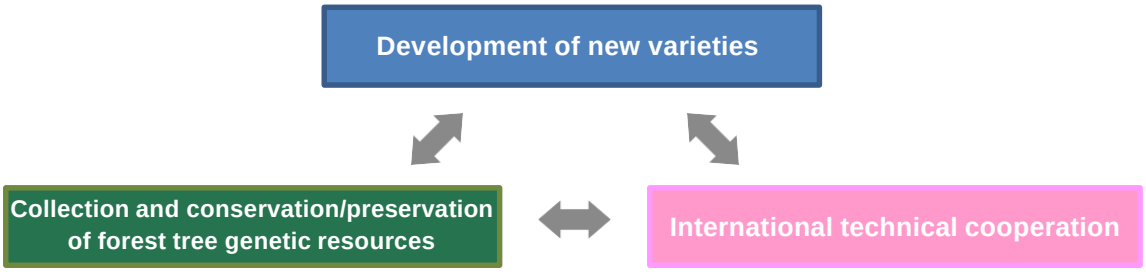
- FTBC is the only forest tree species gene bank, and the scale of gene stock in forest tree species is the largest in Japan.
- Our conservation/preservation forms in national forests are classified into three types, i.e. standing tree (30,000 varieties), seed (14,000 varieties), pollen (4,300 varieties) and DNA (400 varieties).

【Advanced research facilities in leading forest tree breeding R/D】

- Advanced research for speed-up breeding process development of genetically superior varieties by using genetic engineering research facility.
- Developing 3rd generation plus-tree by using crossing (hybridization) glasshouse.
- Conservation/preservation of seeds and pollen in forest tree gene bank storing facilities have been investigated.
- The largest specific net house and GMO isolation field have been utilized for genetic engineering.

c o n t

tree breeding research



Main Tasks

01【Development of new varieties】

- Varieties superior in growth and wood quality (fast growth, trunk straightness and strength)
- Varieties of pollen allergies (pollen free and less pollen)
- Varieties superior in resistance against damages (pine wilt nematode and snow damage tolerance)

02【Collection and conservation / preservation of forest tree genetic resources】

- Tree breeding materials for new varieties of cedar, cypress, etc.
- Endangered tree species and natural heritage trees (part of the National Biodiversity Strategy)

03【International technical cooperation】

- International technical cooperation and collaborative research for climate change adaptation, etc.

contents

Development strategy of new varieties and their outputs

Varieties superior in growth and wood quality

- 9,000 individuals from cedar, cypress, pine and others were selected as plus-trees and have been conserved/preserved
- 287 individuals out of plus-trees have been further selected as new varieties with good growth and trunk straightness
- 686 cedar clones, 315 cypress clones and 140 larch clones, 50 sakhalin fir clones and 4 gmelini larch clones have been selected by crossing between plus-trees, etc.
- 229 less twisted larch varieties have been selected
- 190 cedar clones, 58 cypress clones, 77 larch clones (including 1 gmelini larch clone) and 20 Sakhalin fir clones have been designated as 'Specified Mother Tree (SMT) ' by Minister of Agriculture, Forestry and Fisheries of Japan

These designated SMT are applied by FTBC.
The number of clones and varieties : March 2024

Varieties superior in environmental and other services

- Pollen free cedar : 27 varieties
- Less pollen cedar (Very few male strobilus in normal years, almost non-production pollen in high pollen dispersal years) : 147 varieties
- Less pollen cypress : 55 varieties
- Low pollen cedar (low amount of male strobilus) : 16 varieties
- Cedar with pollen free gene : 3 varieties

Varieties superior in resistance against diseases/pests attack or severe weather conditions

- Pine wilt nematode resistance : 611 varieties (Including 127 varieties of second generation)
- Snow damage tolerance : 46 varieties

Application of high technology to forest tree breeding

- Development of genetic engineering techniques for genetic recombination, genome editing and tissue culture

Status of dissemination of the improved varieties: About 70% of seedlings / saplings for forest planting are from the improved varieties (red pine, black pine, cedar and cypress)

Forest tree breeding and its history

Nurturing rich and beautiful forests through artificial planting will require genetically superior seedlings/ saplings which can grow under severe natural environments over several decades.

In Japan, preliminary trials related to tree breeding will be found in Obi and Hita areas in Kyusyu.

People in those areas have selected plus-trees and propagated saplings from plus-trees scions for more than 400 years. The national-based tree breeding program started around 70 years ago.

In 1954, Forestry Agency launched a nationwide project of plus-trees selection for timber production increase and enhancement of multiple functions from planted forests.

As a core implementing organization for tree breeding in Japan, the first Forest Tree Breeding Stations were established under Forestry Agency in 1957.

As a part of the structural reform of the central government, Forest Tree Breeding Center became an incorporated administrative agency under the Ministry of Agriculture, Forestry and Fisheries in 2001.

Furthermore, in 2007, Forest Tree Breeding Center merged into Forestry and Forest Products Research Institute which is also an incorporated administrative agency. Forest Tree Breeding Center (FTBC) and Forest Bio-Research Center (FBRC) were established under Forestry and Forest Products Research Institute (FFPRI) in 2017.

The tree breeding program has been initiated from plus-trees selection project, then with the reflections of emerging damages/problems inside and outside forests, pine wilt nematode resistant varieties, snow damage tolerant varieties, pollen free/less pollen varieties have been also developed.

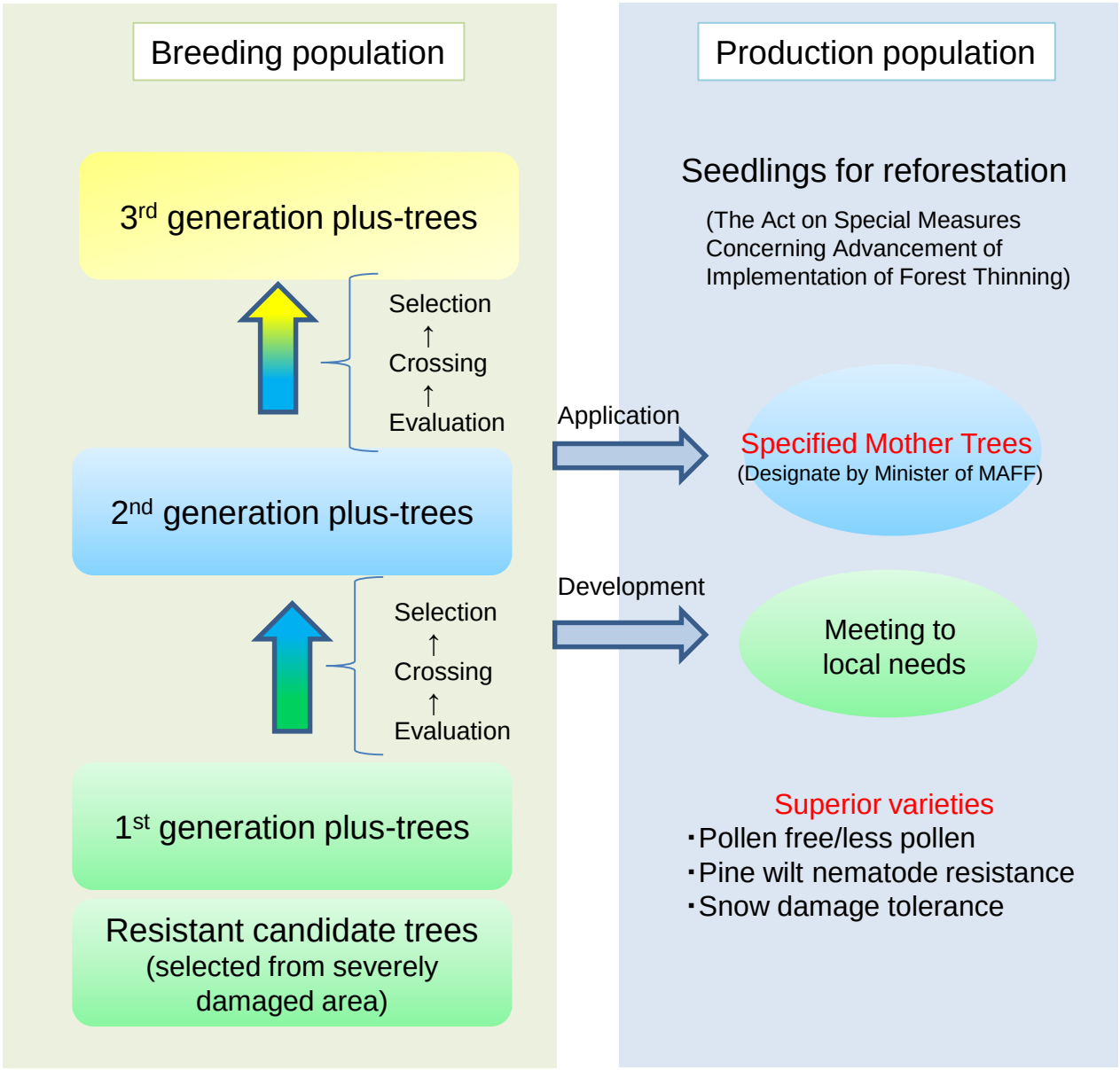
Procedure of forest tree breeding projects

To sustain the efforts of tree breeding and make a good forest planting for several generations, forest tree breeding projects are promoted by two groups, “Breeding population” for mainstream tree breeding and “Production population” to produce seedlings for reforestation.

“Breeding population” is composed of plus-trees that are superior in character such as form, growth, etc. Extensive crossing and selection are performed for the selection of second and later generation of plus-trees.

“Production population” is composed of trees selected from “Breeding population” and they are good varieties for forest maintenance. ‘Specified Mother Tree’ which is superior in growth, is designated by Minister of MAFF, in according with a law ”the Act on Special Measures Concerning Advancement of Implementation of Forest Thinning” for future forest improvement. Superior varieties are developed for local needs including pine wilt nematode resistance, snow damage tolerance and pollen free/less pollen.

Relationship between plus-trees, specified mother tree and superior varieties

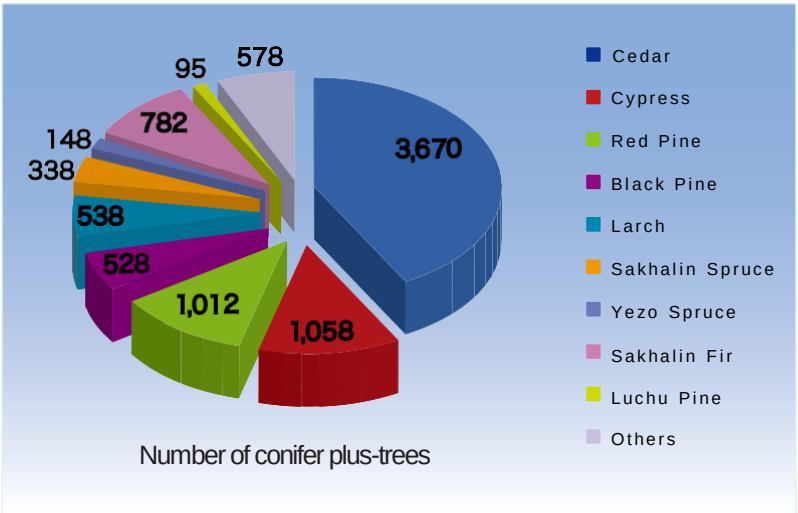


Development of varieties superior in growth and wood quality

1. Selection of plus-trees

Approximately 9,000 trees have been selected as plus-trees from the national forests, which are 30% or more superior in volume and growth compared to adjacent three large trees.

In the plus-trees, there are some trees that include individual of fast growth, trunk straightness and good wood quality that support forest breeding projects. The number of conifer plus-trees in Japan is as follows.



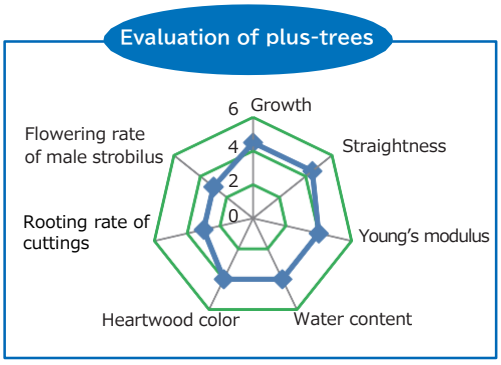
Number of conifer plus-trees

2. Evaluation of plus-trees trait

Progeny test forests are examinations of how plus-trees are genetically superior. Clones and seedlings of plus-trees are reforested. Currently, 1,800 progeny test forests, 2,400ha in total (Each one is from 1ha to 6ha) are maintained and monitored nationwide.

FTBC is conducting periodical monitoring (each 10, 20 and 30 years) of the progeny test forest. Collected data such as stem growth, stem truck straightness and wood quality are compiled and evaluated, then published as “Plus-tree trait tables”.


General progeny test forest of cedar



In plus-trees trait tables, the trait-wise standard score is calculated from the measured data.
Such standard score is converted into a five-degree index. Degree 5 will include 7% of the total.

3. Dissemination and propagation of second generation plus-trees

Developed plus-trees are preserved as foundation stock under clones management at FTBC. These clones are propagated and provided to prefectures that establish seed orchards and scion gardens. FTBC also implements training courses for prefectures on how to produce and manage seed orchards and scion gardens.

FTBC

Conservation of foundation stock (Foundation stock garden)

Foundation stock garden of cedar

Propagation of 2nd generation plus-trees

Propagated by cutting and propagated seedling to distribute prefectures.

Technical training course

Technical guidance of reforestation and management of seed orchards.

Prefectures

Development and improvement of seed orchards and scion gardens in prefectures

※Miniature seed orchard of less pollen cedar variety

Supply of seeds and seedlings

Production of seedlings by seed/seedlings companies

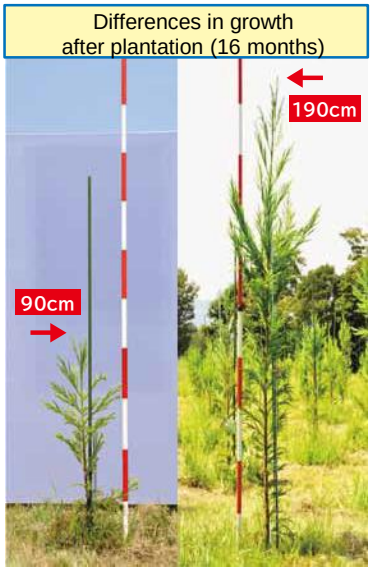
Utilized for reforestation in Japan

※Miniature seed orchard is kept on small size tree and narrow distance. It is effective to work to cultivate seeds quickly.

4. Selection of 2nd generation plus-trees

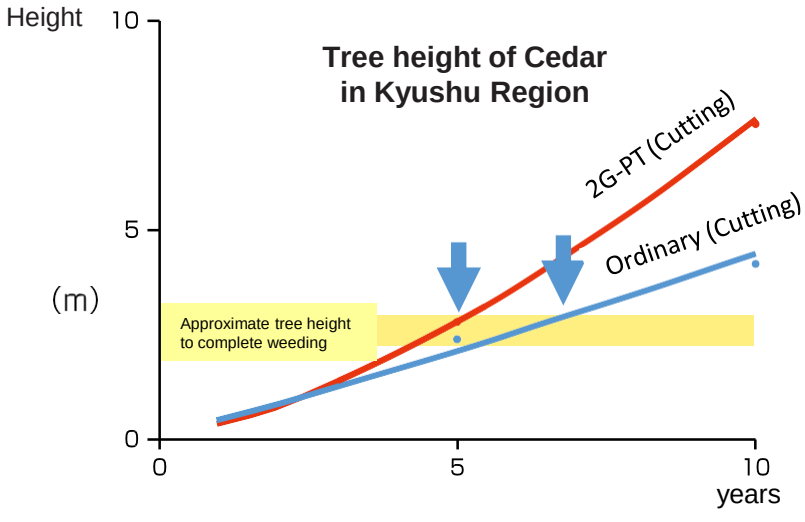
FTBC has reforested progeny test forests (141 sites, 83ha. in total) to select 2nd generation plus-trees (2G-PT), which have superior traits such in growth performance, breeding populations have been established by crosses or open pollination of the 1st generation plus-trees. FTBC is proceeding selection of 2G-PT in more than 9,000 crosses have been made, and the breeding populations are comprised of more than 200,000 trees.

As the 2G-PT is superior in growth and can reduce the number of trees planted and weeding, it is expected to reduce initial investment in reforestation.



Ordinary seedling　　2G-PT clone seedling

2G-PT (5 years old, 8m in height)



(Renovated Hoshi・Kuramoto(2013))

Left figure shows data from test sites for the top 10 superior 2G-PT cedar in the Kyushu region.
2G-PT are particularly superior in growth compared to previous varieties.
So weeding management can be reduced 1 or 2 times and be expected to reduce initial investment in reforestation.

5. Dissemination of Specified Mother Tree (SMT)

To increase the carbon dioxide absorption capacity of forests, Minister of Agriculture, Forestry and Fisheries (MAFF) has designated a superior tree of growth as a “Specified Mother Tree (SMT)” on the basis of the revised Act in 2013.

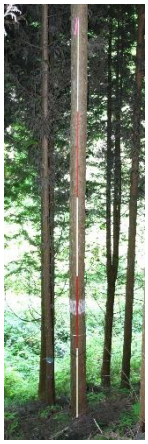
Apart from cedar and cypress, larch and other trees are designated as SMT.

MAFF encourages the use of seedlings obtained from SMT for afforestation.

FTBC has selected superior trees mainly based on 2nd generation plus-trees (2G-PT) and is prompting dissemination of SMT to distribute from the foundation stock.

SMTs in Japan

Sakhalin Fir 2G-PT
(30years old)
Height:19.9m
Diameter:26cm
Hokkaido

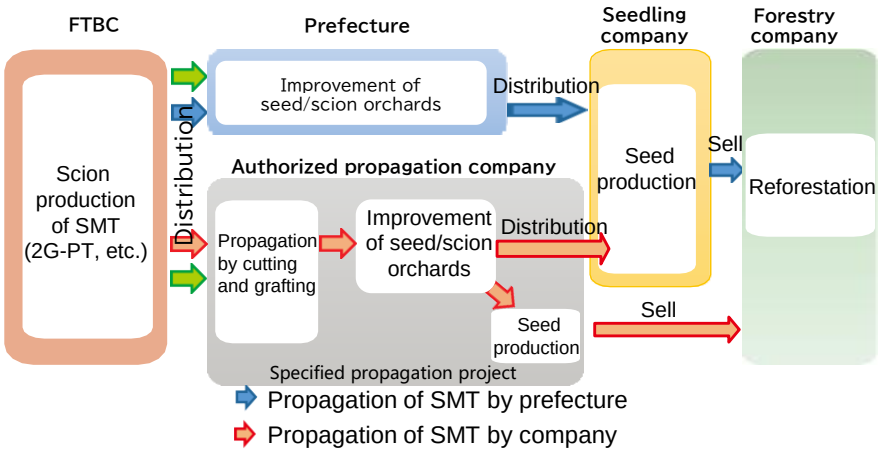


Cedar 2G-PT
(21years old)
Height:12.7m
Diameter:19cm
Kanto

Larch 2G-PT
(30years old)
Height:24.8m
Diameter:25cm
Tohoku

Cypress 2G-PT
(31years old)
Height:17.7m
Diameter:24cm
Kansai

Dissemination system of SMT



- 4years after plantation -

Left: Cedar SMT

Right: Ordinary cedar (Less pollen)

Development of pollen free and less pollen varieties

1. Status on the research and development

Pollen allergy has been one of the socio-medical issues in Japan. FTBC in collaboration with prefectures are carrying to develop less pollen varieties of cedar with approximately 1 % less pollen and cypress, compare to ordinary tree from plus-trees which are superior in growth and straightness. FTBC is also developing pollen free cedar as following which produce male strobilus like ordinary cedar but no pollen at all.

Pollen free variety with straightness called “Soshun” is developed in 2004 and with equivalent quality to 1st generation plus-trees called “Sugi-Mie-Funen (Kansai) No.1” with developed in 2006.

Additionally, FTBC performed artificial crossings between Soshun and 1st generation plus-trees, also 2 new pollen free varieties were developed in 2016 and 2017. Then 14 more pollen free varieties were developed between 2020 to 2022 with collaborated prefecture.

Further more, FTBC developed 3 new pollen free varieties with excellent growth and quality characteristics by using artificial crossing in 2023.

Development of less pollen varieties of cedar and cypress

Ordinary cedar

Ordinary cypress

Less pollen cedar variety (Tenryu No4)

147 varieties of less pollen cedar

Less pollen cypress variety (Nishikawa No.4)

55 varieties of less pollen cypress

Development of pollen free variety of cedar

27 varieties of pollen free cedar (No pollen)

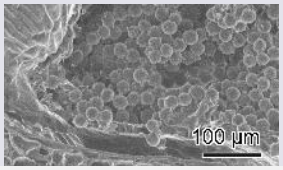
One of 27 varieties has been registered as “Soshun” under the Plant Variety Protection and Seed Act

Ordinary Cedar

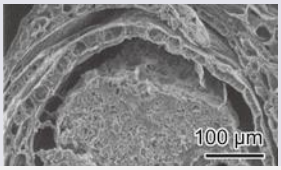
Pollen free Variety

Both these varieties have male strobilus

Cross-section of a male strobilus by microscope observation



Round pollen formulated in anther of male strobilus



No pollen formulated in anther of male strobilus

Supply of less pollen an pollen free varieties for propagation

2. Improvement of pollen free cedar by crossing with plus-trees

FTBC processes developing new varieties of pollen free cedar by artificial crossing between female strobilus of Soshun (pollen free cedar) and male strobilus of 2nd generation plus-trees (2G-PT) with good growth and quality.

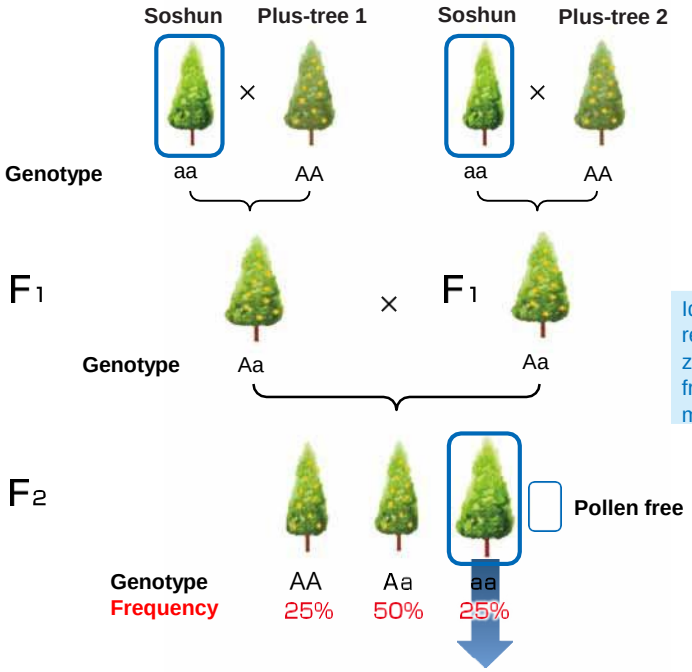
Pollen free genome is inferior. As indicated by Mendel's Law, the first generation (F_1) makes hetero type (Aa) with pollen free genome. Crossing the same hetero type at the second generation (F_2) appears pollen free type (aa).

FTBC planted F_2 and examined for pollen, growth and wood property in the progeny test site. From these F_2 individuals, FTBC developed 2 varieties of pollen free cedar superior growth named "Rin-iku-Hunen No.1" and "Rin-iku-Hunen No.2".

FTBC also developed two varieties of pollen free cedar with stakeholders in 2019. They are expected to be used as a pollen parent for future variety development and seed production in seed orchards.

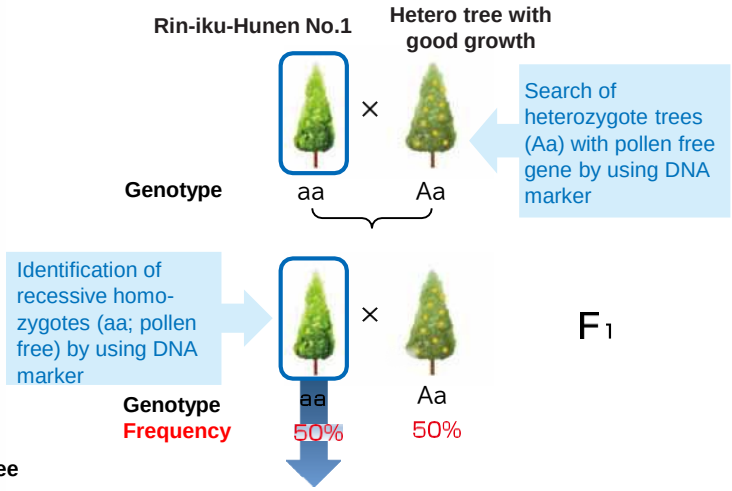
Additionally, the development of DNA markers for pollen free genetic detection of Soshun has helped search hetero genome (Aa) and develop a new variety of pollen free cedar.

Ordinary method of breeding for free pollen cedar



Selection

New method by using DNA marker



Selection

Reduction of crossing generation :
2 generation→1 generation
Reduction of time for identification of pollen free :
Several years →Several days
High accuracy identification rate:100%

More efficient to develop new varieties of pollen free cedar

FTBC developed 2 varieties of pollen free cedar with good growth and no pollen from F_2 of Soshun.

Pollen free cedar "Rin-iku-Hunen No.1"
6 years old, 6.6m in height
※Almost the same as plus-trees

FTBC aims to develop pollen free cedar varieties with better growth by crossing with plus-trees.

Development of pine wilt nematode resistant varieties

1. Situation of pine wilt nematode

Pine wilt nematode (*Bursphelenchus xylophilus*) is serious infections decease of pine trees caused by nematodes which are about 1mm in length carried by longhorn beetles.

This disease was found around 1900, and the damages have been serious since late 1965s, throughout western Japan.

Currently, pine wilt diseases are now being reported throughout Japan without Hokkaido prefecture.

FTBC has been carrying out research and development of pine wilt nematode resistant varieties and 611 new varieties have been developed by 2023.

Longhorn beetle
Longhorn beetles carry pine wilt nematodes and fly from one pine tree to another one.

Pine wilt nematode
(From 0.6mm to 1.0mm in length)
Pine wilt nematodes invade the xylem of pine trees from an open score of the young needle caused by a longhorn beetle bite.
The propagated nematodes in the xylem will cause pine wilt, soon.

＜History of pine wilt nematode and FTBC's activities＞

1905	First pine wilt disease reported in Nagasaki prefecture
1971	FFPRI researchers revealed that nematode causes pine wilt diseases
1978	The pine wilt nematode resistant varieties development project started
1985	FTBC developed 92 pine wilt nematode resistant varieties of red pine (*pinus densiflora*) and 16 pine wilt nematode resistant varieties of black pine (*pinus thunbergii)*
2010	FTBC developed 2nd generation of pine wilt nematode resistant varieties for black pine
2017	FTBC developed 2nd generation of pine wilt nematode resistant varieties for red pine
2018	FTBC improved resistance testing technology and applied it for new variety development

2. Development methodologies of pine wilt nematode resistant varieties

①Selection of candidate trees from disaster area

Select candidate resistant trees from the surviving pine trees in disaster area

Collect seeds or scions from candidate resistant trees

②Examination of resistance through nematode inoculation test

Candidate resistant seedling

Artificial inoculation of nematode

Seedlings after inoculation of pine wilt nematode

Judgement

Numbers of pine wilt nematode resistant varieties

Red Pine 326

Black Pine 285

(March 31,2024)

※Include 60 red pine varieties and 67 black pine varieties of the second generation from crossing between pine wilt nematode resistant varieties

③Development of seed orchards

36 red pine seed orchards and 57 black pine seed orchards have been established in the Tohoku, Kanto, Kansai, and Kyushu region prefectures to produce pine wilt nematode resistant seed

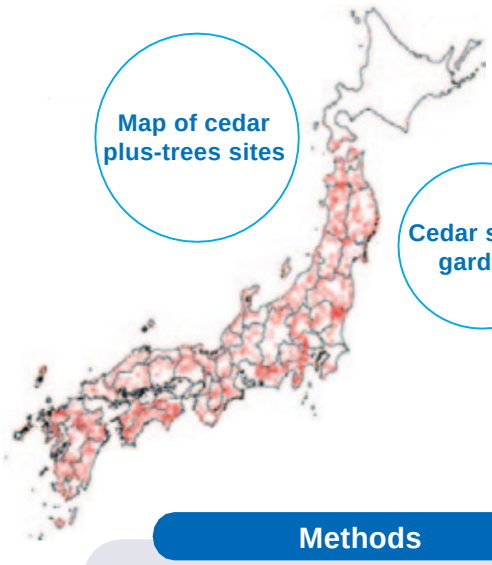
(March 31, 2023)

Seed orchard developed by resistant varieties

④Dissemination of resistant seedlings

Propagated resistant seedlings of black pine are mainly planted in the coastal conservational

DNA-based traceability system of plus-trees



More than 3,000 clones of cedars have been selected as plus-trees nationwide. Those plus-trees have been clonally propagated, and planted in progeny test forests as well as seed/scion orchards.

As it is difficult to distinguish these clones from the outside, FTBC is using DNA to promote more accurate clone management.

Methods

Collecting DNA sample

Processing by liquid nitrogen

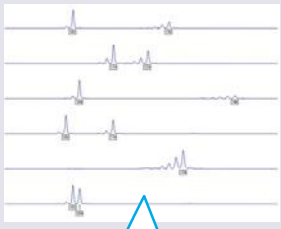
DNA extraction

Polymerase Chain Reaction (PCR)

DNA preservation (some parts)

Confirmation of PCR result

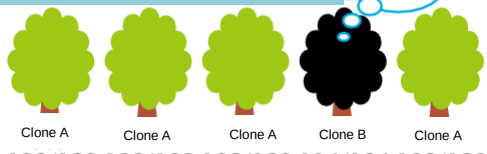
Results



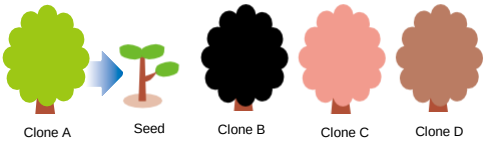
The length of DNA amplified varies from clone to clone. We can discriminate the part as a difference in the degree of mobility by using a sequencer.

Clone management; in case of Clone A

Wrong!



Seed orchards management; in case of seed from Clone A



When seeding from Clone A has a genotype of 102/148, the candidate pollen donner of this seedling will be very likely Clone C.

DNA analysis enables us to do not only high-accuracy clones but also parentage of breeding materials.

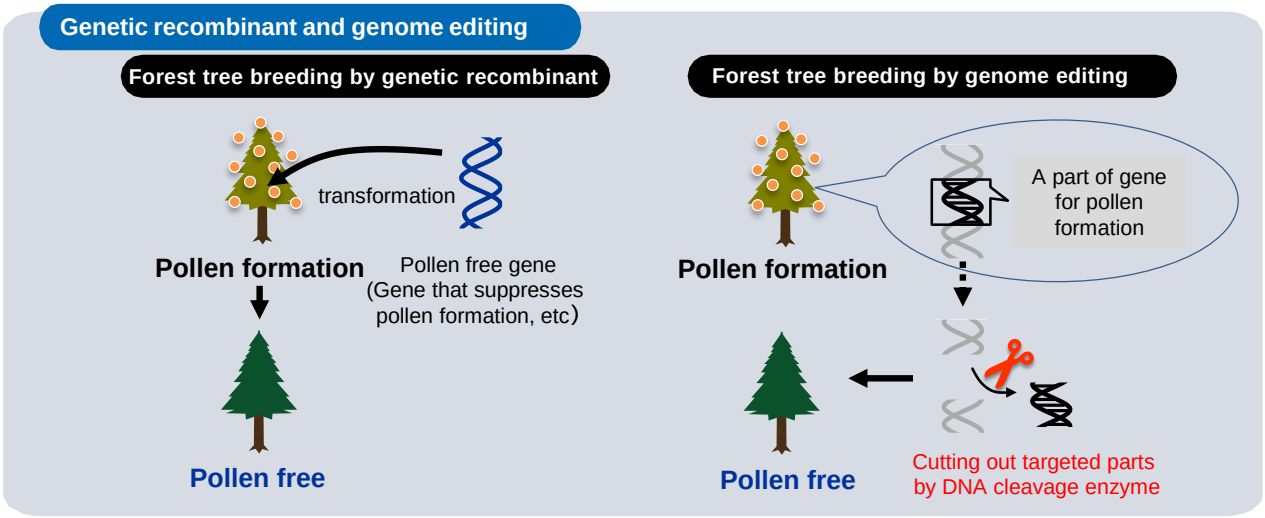
Bio-technology in forest tree breeding

1. Development of pollen free cedar through genetic recombinant and genome editing

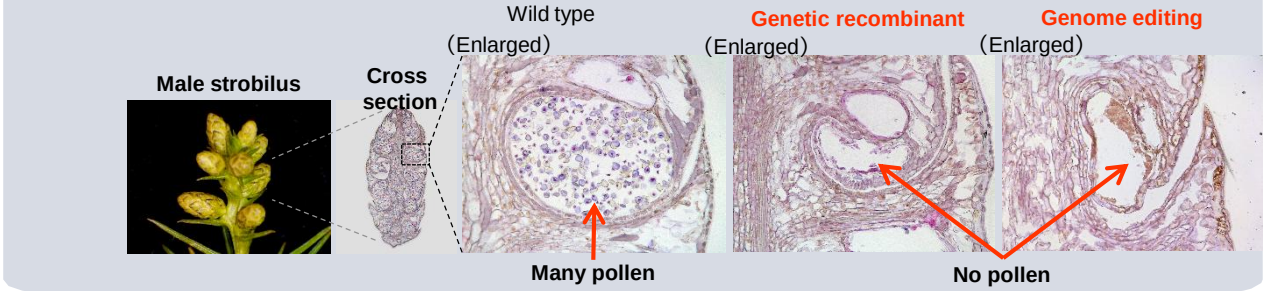
Genetic recombinant is a technology that introduces only the target gene, enabling efficient and rapid breeding. Genome editing technology, which can modify the function of a plant's own genes, has also attracted attention in recent years.

FTBC is researching and developing pollen free cedar varieties with superior growth and wood quality by using these advanced biotechnologies.

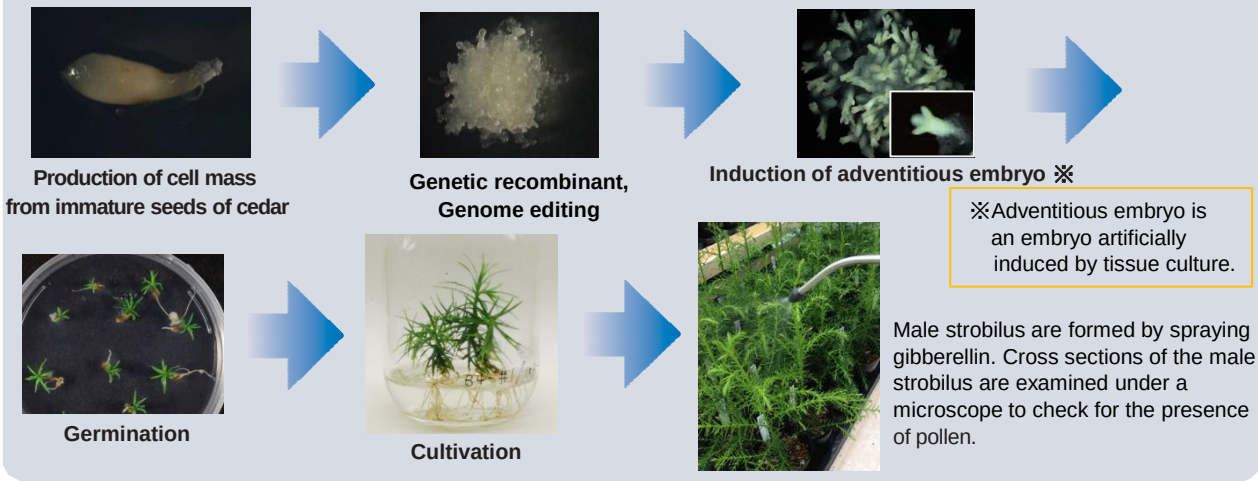
Genetic recombinant and genome editing



Inside of male strobilus in pollen free cedar



Actual procedure for pollen free cedar production



The only forest tree gene bank in Japan

Necessity of forest tree genetic resources conservation

Forest tree genetic resources have been providing various forest products on which human beings depend since ancient times. These genetic resources will be expected to provide various services in the future with science and technology development.

Also, conservation of forest biodiversity has been strongly called in recent years. If these genetic resources were lost, the same genetic resources cannot be reproduced.

Therefore, these genetic resources have to be conserved and inherited to the next generations.

Outline of forest tree gene bank program

FTBC is the only forest tree gene bank program in Japan and has the largest stock of woody plants.

With taking due consideration to the application value of genetic resources, needs and priority of conservation, FTBC is systematically conducting exploration and collection of genetic resources, and Conserving / preserving such resources by seeds, pollens, DNA, and propagated individuals.

FTBC is also conducting trait analysis of collected genetic resources for identification of potential use as well as distributing such resources for research purposes.

Status of conservation / preservation of forest tree genetic resources

Method and form of conservation/preservation

Conservation and preservation of forest tree genetic resources are performed by combining “In-situ” and “Ex-situ” from the characteristics of the target tree are many varieties, long-lived, extremely large plants, and so on.

In-situ conservation/preservation

In-situ conservation is a method of preserving the forest genetic resources that make up the forest as a whole by preserving the forest, or habitat, in which the trees originally reside.

Conservation is carried out in protected forests set aside in national forests, etc.

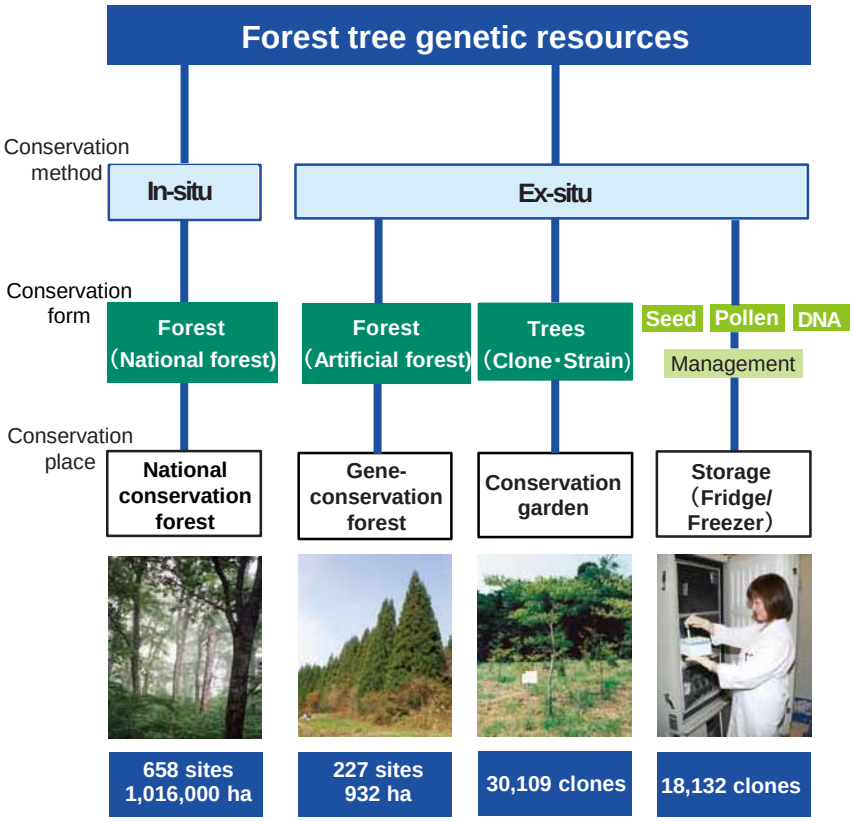
Ex-situ conservation/preservation

Ex-situ conservation is a method of preservation that involves taking genetic resources outside their original habitat.

They are conserved by a combination of the three methods as follows.

1. Methods to preserve genetic resources in the form of forests as a population by creating planted forests with genetic resources taken from the habitat.
2. Methods of preserving of genetic resources by mother tree from the habitat area and storage in adult form as clones or strains in a conservation forest on the FTBC premises.
3. Methods of preserving germplasm such as seeds and pollen collected from inside and outside the habitat, or as DNA, which is stored in facilities in freezers or other storage facilities.

Method and form of conservation/preservation on forest tree genetic resources



(March.31,2024)

Outline of forest tree gene bank program

Exploration/Collection
Exploration and collection of scions and seeds of genetic

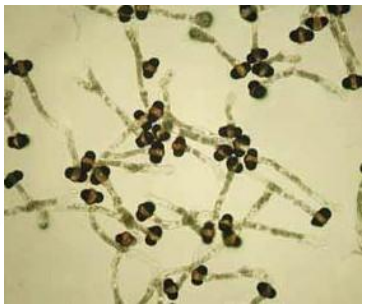
Collection of scions from “Katsura in Ousen’s fall”, one of “Hundred Giant Trees in Japan” designate by Forestry Agency

Propagation/Conservation
Propagation by grafting and cutting. Conservation in gene stock garden or storage

Propagation by cutting of Japanese red maple which is endangered species

Evaluation of various traits
Traits analysis and evaluation on the gene stock

Collection of various trait such as growth



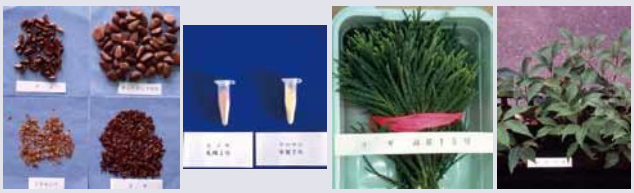
Trait analysis on pollen germination rate and ecological/morphological features

Data management
Establish a database of information on the collection location, history information, conservation form, and traits evaluation of forest tree genetic resources

Data server

Genetic resource management linked to an integrated breeding database

Distribution
To meet the demand for research purposes, forest tree genetic resources will be distributed in various forms upon the request



Seeds　Pollen　Scions　Seedlings

Outcomes

New varieties	New Products	Academic advances
Distribution of pollen for artificial crossing	Distribution of pollen for the development of pollen allergy products	Distribution of scions for elucidation of genetic variation

Preservation of endangered species

Example: Ogasawara-Guwa (*Morus boninensis)* and Yakutane –Goyomatsu *(Pinus amamiana*)

Morus boninensis

Wild ***Morus boninensis***

Ogasawara-Guwa *(Morus boninensis*) was dominant tree species of original moist forest of Bonin Islands before. But it has been listed as “Critically Endangered” on Red List of Ministry of Environment since 2012.

The number of forest stands is drastically decreased due to logging pressure and high demand of material quality, now only 120 trees remain in the islands.

In order to avoid their extinction, FTBC has started to save them by propagation and ex situ preservation since 2004, and return them to the islands.

Re-Plantation in Bonin Islands

Bud in winter

Tissue culture

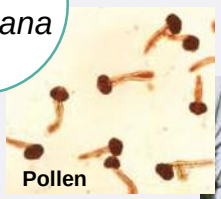
Growth with leaves

Propagation and rooting

Return to Bonin Islands

Acclimatization

Pinus amamiana



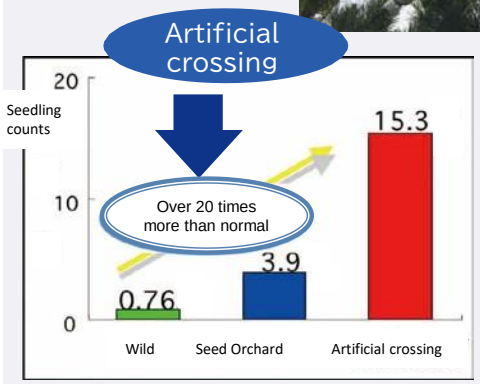
Pollen

Cone

Yakutane-Goyomatsu (*Pinus amamiana)* which grows naturally on two islands (Yakushima and Tanegashima) is listed as “Endangered” on Red List of Ministry of Environment.

The number of seedlings from one cone has been increased 20-fold compared to wild *Pinus amamiana* by applying our technologies of seed orchard and artificial crossing for pine and other species.

FTBC promote ex-situ conservation of genetic resources efficiently by using these seedlings.



Number of Seedlings from a cone

Budding of *Pinus amamiana*

Returning home of successor clonal seedlings of genetic resources such as giant trees and famous trees

SOS Call to Gene Bank

FTBC is processing clone multiplication service for heritage/memorial individual trees. Upon a request, the endangered individual's successor trees are propagated through cutting and grafting and also returning back. At the same time, FTBC conserve and utilize these trees as research resources.

FTBC have received 333 requests so far and sent back home 255 places with 317 seedlings. Some of the mother trees in SOS have fallen down or died by typhoons or disease.
(March 31, 2024)

Pine (*Pinus thunbergii*)
Kenroku-garden,Ishikawa Pref.

Katsura
(*Cercidiphyllum japonicum*)
Hokkaido Pref.

Plam (*Prunus Mume)*
Kiyomizu temple, Kyoto Pref.

Wisteria
(*Wisteria floribunda)*
Iwate Pref.

Returning home of successor seedlings which mother tree was damaged by typhoon.

Cider (*Cryptomeria japonica*)
Ubu Shrien, Kumamoto Pref.

Planted by 18th president of USA 120 years ago.

Lawson's Cypress
(*Chamaecyparis lawsoniana*)
Tokyo Pref.

Famous Black pine from Edo era.

Black Pine (*Pinus thunbergii)*
Tokyo Pref.

● Location of returning

International technical cooperation and collaborative research

FTBC is developing forest tree breeding technologies to adapt to climate change through international technical cooperation and collaborative research.

Technical cooperation

Forest tree breeding project in Kenya

Partner: Kenya Forestry Research Institute（KEFRI）
Duration: 2012-2026
Outline: FTBC has been supporting and guiding research on the breeding of Kenyan native species *Melia volkensii* (Melia) and *Acacia tortilis* (Acacia) through a JICA technical cooperation project since 2012.

1st Phase	**Project on Development of Drought Tolerant Trees for Adaptation to Climate Change in Drylands of Kenya** 2012-2017
2nd Phase	**Capacity Development Project for Sustainable Forest Management in the Republic of Kenya (Tree Breeding)** 2017-2021
3rd Phase	**Project for Strengthening Forestry Sector Development and Community Resilience to Climate Change through Sustainable Forest Management and Landscape Restoration （Tree Breeding ）** 2022-2026

【Melia(*Melia volkensii*)】

Melia plus-trees survey

Collection, Nursing

1st Generation Melia seed orchard

Nursing, Evaluation, Selection

Melia progeny test site

Nursing, Evaluation, Selection

2nd Generation Melia seed orchard

Collaborative research

DNA analysis

Artificial Crossing

Cutting test

【Acacia(*Acacia tortilis*)】

Acacia plus-trees survey

Collection, Nursing

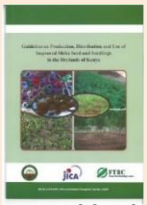
Acacia seed stand and test site

Nursing, Evaluation, Selection

Row thinning

Biomass volume survey

【Outcomes】



Manual for the creation of seed orchard

Guidelines for the conservation of genetic resources

Iriomote Tropical Forest Tree Breeding Technical Garden (TFTBTG)
- Development base of breeding technology for tropical tree species -

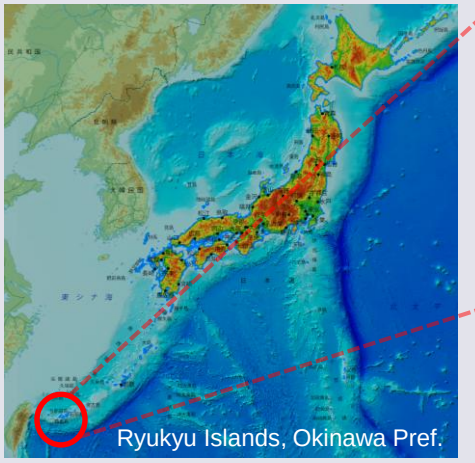
Summary of TFTBTG

TFTBTG was established on Iriomote Island which is located in Okinawa Prefecture (the subtropical zone) in 1996.
The objective of TFTBTG was to develop and research various technologies for tree breeding and improving the traits of fast-growing tree species in the tropics and subtropics with following three main pillars.

(1) Development of tree breeding technology for tropical and subtropical tree species.
(2) Technical guidance on overseas forest tree breeding.
(3) Conservation of genetic resources of tropical tree species.

Iriomote Island
Location: 2,000km away from Tokyo
Area：290km^2
Forest rate：90%
Climate：Subtropical maritime
Mean temperature：23.9℃*
Annual precipitation：2,240mm*

*：Average from 1991 to 2020



Iriomote TFTBTG
Location：Komi,Taketomi town,Okinawa Pref.
(N24˚19'43, E123˚54'34)


TFTBTG office


Exhibition hall


Green house


Test site

(1)Development of tree breeding
・ Propagation guidance
・ Crossing technique
・ Evaluation of trait property



(2)Technical Guidance
・ OJT for overseas trainees
(Grafting, Cutting and other technique)


(3)Conservation of genetic resources
（with demonstration)
・ Tropical forest trees
・ Rare species in Ryukyu Islands



Clonal propagation technique and forest tree breeding manual

Clonal propagation methods for Acacia and Eucalyptus species

- 3 types of clonal propagation methods were tested in TFTBTG for the 4 main species in order to contribute to regeneration of degraded tropical forests.

Creation of a forest tree breeding manual for fast-growing tropical trees

- TFTBTG created a manual explaining how to proceed with forest tree breeding of fast-growing tropical tree species for afforestation on degraded lands, etc., based on breeding theory and past practical examples.

＜Photo＞
Breeding manual of fast growing tropical forest tree species (Japanese version only)

Development of breeding technology of genus Acacia

1. Flowering phenology
TFTBTG found that the flowering period of *Acacia auricaliformis* varies greatly between years and clones, and there was a long period that did not overlap with the flowering period of *Acacia mangium*, revealing that there were few opportunities for natural crossing between two species.

2. Comparison of artificial crossing methods
TFTBTG developed that the most efficient method for control pollination that conducting artificial pollination in the morning by using tube bore the highest pod formation rate.

3. Pollen storage test
TFTBTG investigated the germination rate from one day to one year later after freezing and storing pollen, and found that the germination rate did not decrease significantly for all clones until one year after storage.

4. Demonstration test of control pollination to breed Acacia Hybrid
As a result of reciprocal crossing between *A. mangium* and *A. auricaliformis*, it was confirmed that inflorescences were formed in both combinations and was revealed that the occurrence rate of hybrids was high by DNA analysis.

5. Creation of a breeding technique manual for the genus Acacia
Based on the findings in 1 to 4 above, “Breeding Technique Manual for the Genus Acacia” was created.

＜Photo＞
Breeding Technique Manual for the Genus Acacia (Japanese version only)

Preservation of useful tree genetic resources in Ryukyu Islands

TFTBTG is conducting research to preserve of indigenous tree species＊.

- Seedling and clonal propagation tests
- Development of control pollination for *Schima liukiuensis*
- Seedling and clonal propagation of *Michelia formosana*
- Breeding research for *Nothapodytes nimmonianus* and *Nothapodytes amamianus*
- Research into practical use of cuttings of *Garcinia subelliptica*

＊Ryukyu Islands are designated as world heritage

Collaborative research

Breeding research on *Calophyllum inophyllum* with superior wind high tide protection

Partner：Taiwan Forest Research Institute (TFRI) (2011-2028)
Secretariat of the Pacific Community (SPC) (2012-2022)

Species：*Calophyllum inophyllum*
Outline：*Calophyllum inophyllum is* planted as coastal disaster protection on the Sakishima Islands in Okinawa prefecture and is ocean-dispersing tree which is widely distributed in tropical and subtropical areas of the Pacific ocean. TFTBTG is analyzing genetic variation of *Calophyllum inophyllum* in various regions and developing varieties that grow fast and have good quality to cope with the severe coastal disasters like wind and high tides associated with global warming.

Test site in Iriomote from UAV

Roadside trees of *Calophyllum inophyllum* for storm protection (Ishigaki Island)

Survey of progeny test site (Iriomote Island)

Meeting about *Calophyllum inophyllum* at TFRI

Test site of *Calophyllum inophyllum* in Taiwan

Demonstration test of artificial crossing technique of genus Acacia in Vietnam

Partner：Oji Green Resources Co.Ltd. (2013-2022)

Species：Genus Acacia (*Acacia mangium* × *Acacia auriculiformis*)
Outline：TFTBTG developed a new genus Acacia (hybrid) by using the Acacia artificial hybridization technique which is developed by TFTBTG. TFTBTG selected candidates with excellent growth and wood property from test sites and set up progeny test site, and then, TFTBTG determined some superior trees.

Breed Acacia hybrid by efficient artificial crossing technique

Set up the progeny test site and evaluate a variety of trait such as growth

Select superior candidate trees

Conduct clonal propagation of selected superior candidate trees and set up progeny test site

Acceptance and guidance of trainees

TFTBTG including FTBC, accept JICA overseas trainee in order to provide guidance as well as accept site visit for visitor such as government agencies, educational institutions and NGOs.

Training of tropical seedlings management for JICA overseas trainees

Training of drought tolerant tree breeding for KEFRI (Kenya Forest Research and Institute) staff

Pre-dispatch training for MAFF (Ministry of Agriculture, Forestry and Fisheries) staff

Site visit for NGO (Yaeyama Forestry Research Association)

【Advanced research facilities in leading forest tree breeding R/D】

Crossing (hybridization) glasshouse

This is a glasshouse with closed hybridization booth that can shut out pollen from the outside and automatic watering and composting.

Foundation product facility

FTBC has developed technology for increasing the production of original seedlings, and established foundation product facility to supply original seedlings of SMT to prefectures and others. This facility is capable of controlling temperature, day length and carbon dioxide concentration to promote the growth of seedlings at any season.

Forest tree genetic resources conservation facility

This is the only gene bank in Japan that collects and preserves forest tree genetic resources to contribute to species diversity and genetic diversity within species.

Seeds and pollens are stored in ultra-low temperature freezers for long-term safe storage.

Seed（-20℃）

Pollen（-80℃）

Genetic engineering research facility

This facility is a laboratory for evaluating on testing, growing, and safety of genetically modified forest trees.

Genome tree breeding research facility

This is a laboratory with growing environment control room where environmental requirements can be freely set to investigate genes that are activated in response to environmental factors, a next-generation sequencer that can read a large number of sequences at once, a two-dimensional chlorophyll fluorometer for detailed and rapid measurement of trait phenotypes, and a near-infrared spectrometer (NIR) .

FTBC is engaged in genome breeding research for early development of superior varieties.

Specific net house and Genetically Modified Organism（GMO）isolation field

Specific net house is a greenhouse for growing and evaluating genetically modified forest trees that have been tested in laboratory or closed greenhouse. Fine-meshed nets are fully equipped to avoid invasion of insects carrying pollens.

GMO isolation field is an evaluation field after a specific net house. This is the largest specific in Japan and is isolated by 60m x 54m in space with 8m height fences, 1m depth sealed concrete fence, with invasion sensors and cameras.

Regional Breeding Office	Breeding tree species
Hokkaido(HRBO)	Larch, Hybrid larch, Sakhalin Fir, Yezo spruce
Tohoku(TRBO)	Cedar (snow area), Larch, Red pine, Black pine
Kanto(FTBC/FBRC)	Cedar (less pollen), Larch, Cypress, Black pine
Kansai(KRBO)	Cypress, Cedar (less pollen), Red pine, Black pine
Kyushu(KRBO)	Cedar (clonal forestry), Cypress, Black pine,Luchu pine

Location of FTBC/FBRC, Regional Breeding Office and others

map

Forestry and Forest Products Research Institute
Forest Tree Breeding Center (FTBC)
Forest Bio-Research Center (FBRC)

3809-1 Ishi, Juo, Hitachi, Ibaraki 319-1301, Japan
TEL : +81-294-39-7013 FAX: +81-294-39-7306
E-Mail : ikusyu@ffpri affrc go jp
URL : (FTBC) https://www.ffpri.affrc.go.jp/ftbc/
(FBRC) https://www.ffpri.affrc.go.jp/fbrc/