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New Strategy of Forest Tree Breeding for Society, Forest Science, and Forestry in Korea[1)]

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ABSTRACT : Social and scientific changes, i.e., global warming, desertification, pollution, biodiversity, bioenergy, plant variety protection, biotechnology, timber demand, reforestation in North Korea, and etc., were reviewed for new strategy of forest tree breeding in Korea. Diversified breeding goals, globalization of breeding target species, multidisciplinary research approaches, manpower networking, establishment of new administrative and research units in KFS and KFRI were proposed. Principles suggested for new tree breeding strategy are: 1) multi-disciplinary approach in settlement of objectives, breeding methods, and etc., 2) expansion of target trees including foreign species, 3) fulfillment of both domestic and international demands for forest tree breeding, 4) establishment of breeding program well-grounded on genetic resources conservation, 5) acknowledgement of breeding products (i.e., variety, technique, gene, and etc.) as goods, and 6) provision of more research opportunities for young scientists. Lastly, ongoing tree breeding project in Indonesia and NTFP R&D Center at the College of Forest and Environmental Sciences, Kangwon National University were introduced as examples of desirable breeding projects based on target species diversification, multidisciplinary approach, and manpower networking.

Keywords : Forest, Forestry, Society, Breeding strategy, Global challenge

INTRODUCTION

Korean forest was denuded by indiscreet logging by Japanese colonization policy during the Second World War and illegal felling of tree during the disorder period from the independence from Japan up to the end of Korean conflict. The forest rehabilitation policy since early 1960's led the whole nation's attendance for the reforestation, and was so successful that the Reforestation Movement recovered the Korean forest completely.

The Korean forest (6,394,000 ha) covers 64.3% of the whole land. It consists of conifer forest (42.2%), broad-leaved forest (26.2%), mixed-forest (29.3%), and the other (2.3%). The average stock per ha reached 79 m^3 in 2005. However, it hardly satisfies the demand of the related industry because more than 62% is under Age Class III, which has limited timber utilization and only 8% of industry need is supplied domestically. Thus the one of the nation's task related with forest and forestry is self-supported timber supply.

It is quite often told that forest tree breeding among many areas of forest sciences gave a great contribution to the Reforestation Movement of Korea. Most successful trials are found in hybridization and introduction of breeding. *Populus alba* x *glandulosa* showed a remarkable growth and adaptability when compared with both parents. *Pinus rigida* and *Pinus taeda* were introduced successfully from the United States to afforest the infertile, denuded forest land. Later it was used to establish hybrids, which showed a combination of parental traits and a high adaptability to various soil and climate conditions. However, the hasty, imprudent selection of plantation sites and varieties caused the serious problems in growth in some places and the efficient use of their lumber is in doubt. We also missed the chance to study their utilization intensively.

Hybridization breeding of chestnut is one of the representative successful cases, too. Many varieties have been

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developed and quantitative and qualitative traits improved. It has given immeasurable results in the increase of forest owners' income and the maintenance of Korean tradition. Now chestnut possesses the first place in terms of money among exported forest products. However, many challenges are on the rise continuously to rival Chinese variety and to adjust to the consumer's taste, at home and abroad.

Many varieties of rose of Sharon (*Hibiscus syriacus*) were developed. It is beyond controversy that they are the pride of Korean people and how much they contributed to the elevation of aesthetic value of national flower.

These establishments of forest tree breeding in Korea, led by the late Dr. Hyun and many other forest scientists in Korea Forest Research Institute (KFRI), have been quoted by many foreign scientists and studied as models for successful tree breeding programs throughout the world.

But our past forest tree breeding has been remained something to be wanted, in some points of view, at the present and for the future. One of them is that we did not know exactly about global warming caused by industrialization and we could not practice tree breeding to prepare for that situation. Still, plants with high environment remediation and resistance to pollution are recommended strongly to be raised. Another of them is a very limited study about foreign tree species and forest together with lack of administrative and financial support for afforestation abroad, even though we imported more than 90% of our timber demand since 1960's.

In this presentation, many problems at issue inside and outside forest science and forestry at home and abroad will be looked into. It may be said that they will remain open to question without answer. However, strategy of forest breeding should be discussed to cope with such challenges and thus to provide the physical and moral welfare of society. From these aspects of our view, this article, basically, includes climate change, biodiversity, timber self-sufficiency, income of forest owner, UPOV (International Union for the Protection of New Varieties of Plants), and etc.

BACKGROUND or CHALLENGES

As observed in the INTRODUCTION, we have gained various results, for country, society, and forest science and technology, in forest tree breeding. Even though some difficulties are still remained to be resolved at the global level of science and technology, our scientific level and capacity in forest tree breeding are far advanced. By these facts, our discussions and suggestions to start new development of forest tree breeding are optimistic. However, final gain of such development will not be effective and fruitful without our efforts and co-operations.

It is necessary that we should check the demand and necessity in the future, considering the present status - global, social, and scientific - in general. Looking through home and abroad situations to be related forest science and forestry is necessary to open a new ground for forest tree breeding.

UNFCCC (United Nations Framework Convention on Climate Change- http://unfccc.int/2860.php), Kyoto Protocol and Clean Development Mechanism (CDM)

UNFCCC or FCCC is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro in 1992. The treaty aimed at reducing emissions of greenhouse gas in order to combat global warming. The treaty originally contained no enforcement provisions; it is therefore considered legally as non-binding resolution. The principal update is the Kyoto Protocol, which has become much better known than the UNFCCC itself. Now it is known that 189 countries joined. Korea was classified as Non-Annex I Parties at the Convention and was not obliged to reduce greenhouse gas emission between the years 2008-2012, defined as the first emissions budget period.

The Kyoto Protocol is an agreement made under UNFCCC. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs), or engage in emissions trading

if they maintain or increase emissions of these gases. Proponents also note that Kyoto Protocol is the first step as requirements to meet the UNFCCC and will be modified until the objective is met, as required by UNFCCC.

The agreement came into force on February 16, 2005 following ratification by Russia on November 18, 2004. As of December 2006, a total of 169 countries and other governmental entities have ratified the agreement. Notable exceptions include the United States and Australia. Other countries, like India and China, which have ratified the protocol, are not required to reduce carbon emissions under the present agreement.

Under this agreement industrialized countries will reduce their collective emissions of greenhouse gases by the average of 5.2% compared to the year 1990. National limitations range much depending on the countries.

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment (so-called Annex 1 countries) to invest in emission reducing projects in developing countries. This is regarded as an alternative to what is generally considered more costly emission reductions in their own countries. Because tree has a fine mechanism as carbon sink, overseas afforestation under this consideration is quite fascinating to the countries like Korea highly dependent on heavy and chemical industry and their export.

CBD (Convention on Biological Diversity- http://www.cbd.int/default.shtml)

Based on UN news release on the 22nd day of May, 2007 (http://www.un.org/apps/news/story.asp?NewsID=22646&Cr=biodiversity&Cr1=), three species become extinct every hour; every day, up to 150 organism species come to extinction; and every year, between 18 to 55 thousand species disappear mainly owing to human disturbance.

CBD is an international treaty that was adopted at the Earth Summit in Rio de Janeiro in 1992. The Convention has three main goals:

1) conservation of biological diversity (or biodiversity);
2) sustainable use of its components; and
3) fair and equitable sharing of benefits arising from genetic resources.

In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key document regarding sustainable development.

Biological diversity - or biodiversity - is the term given to the variety of life on Earth and the natural patterns it forms. It forms the web of life of which we are an integral part and upon which we so fully depend. This diversity is often understood in terms of the wide variety of plants, animals and microorganisms. So far, about 1.75 million species have been identified, mostly small creatures such as insects. Scientists reckon that there are actually about 13 million species, though estimates range from 3 to 100 million.

Individual country implementation:

Several of the signatory countries have established Biodiversity Action Plans to implement the outcome of the convention. For example, the United Kingdom, New Zealand and Tanzania have carried out elaborate responses to conserve individual species and specific habitats. The United States of America, a signatory who has not yet ratified the treaty, has produced one of the most thorough implementation programs through species Recovery Programs and other mechanisms long in place in the USA for species conservation.

UPOV (The International Union for the Protection of New Varieties of Plants- http://www.upov.int)

UPOV is an intergovernmental organization with headquarters in Geneva, Switzerland. UPOV was established by the International Convention for the Protection of New Varieties of Plants in Paris in 1961 and it was revised in

1972, 1978 and 1991. The objective of the Convention is the protection of new varieties of plants by an intellectual property right. Sixty-four countries joined UPOV throughout the world as of May 16, 2007. By codifying intellectual property for plant breeders, UPOV aims to encourage the development of new varieties of plants for the benefit of society.

For plant breeders' rights to be granted, the new variety must meet four criteria under the rules established by UPOV.

1) The new plant must be novel, which means that it must not have been previously marketed in the country where rights are applied for.
2) The new plant must be distinct from other available varieties.
3) The plants must display homogeneity.
4) The trait or traits unique to the new variety must be stable so that the plant remains true to type after repeated cycles of propagation.

Protection can be obtained for a new plant variety however it has been obtained, e.g. through conventional breeding techniques or genetic engineering.

Bio-energy

Bioenergy resources such as forestry and agriculture crops, biomass residues and wastes already provide about 14% of the world's primary energy supplies. Bioenergy offers cost-effective and sustainable opportunities with the potential to meet 50% of world energy demands during the next century, and at the same time meet the requirement of reducing carbon emissions from fossil fuels (IEA Bioenergy- http://www.ieabioenergy.com/IEABioenergy.aspx).

Since two energy crises in 1973 and 1978, it is said that there will be more in the future. In 2006, crude oil price in the world market hit the daily permissible ceiling and reached up to US$ 100 per barrel.

Eighty % of Korea oil consumption is based on Dubai oil. According to the latest report of British Petroleum in U. K., Korea consumed 2.1% of the global energy consumption and ranked the 9th.

The Korean Government released the various policies on the new and renewable energy sources including forest biomass. Among the policies, "National Basic Plan for the Development of Resource and Technology for Energy 2006-2015" is finally presented to the public on May 18, 2006 (http://www.nstc.go.kr). It focuses on the development of 5 core technologies. Those are, energy proficiency, reduction of green-house gas, new/renewable energy, electric power, and resources survey/management. For the new/renewable energy, it recommends that every governmental and private organization should accomplish its work and research by the year 2012. Governmental investment, about US$ 12.15 trillion by year 2015, in five main fields are expected to provide an import substitute effect of US$ 47.4 trillion and employ new 300,000 people. The Plan showed the construction of Eco-Energy City, 108 road maps for each division of energy and resource development, and etc. About 5% of the whole energy, according to the Plan, will be supplied by the new/ renewable energy in 2011. To increase its ratio from 2.2% in 2005 to 5% in 2011, US$ 1.58 trillion (about 20.44% of the whole investment for five core technologies) is necessary.

The studies of various aspects on forest bio-mass energy are quite promising based on the Plan by Korean Government and the need of the society.

National and global welfare

Rapid urbanization and industrialization pollute local environment to which trees cannot adapt themselves well within a short period. As people are heavily dependent on forest to mitigate and avoid such hazards, trees resistant to such conditions will be quite necessary to improve such environment worldwide. If the situation of this phenomenon is not changed easily in the near future, more emphasis should be given to local, national and global welfare than economic benefit from forest trees. According to Korea Forest Service, the non-economical benefit from forest was estimated about K₩62 trillion in the

fiscal year of 2005 and it will reach K₩100 trillion in 2010. This will develop into one of the major approaches of tree breeding different from those of crop breeding.

The world climate fluctuates highly and progressive desertification occurs in many countries. Koreans suffer every spring the floating yellow dusts from Gobi desert. The Basic Plan (2007~2016) for Mongolia Green-Belt Establishment Program (2005~2035), a joint adventure between Korea and Mongolia, is a new challenge for Korean forest sector which experienced a successful reforestation. The Korean Government will provide K₩95,000 million to its counterpart during the period. China has already launched a massive campaign to plant trees around the Gobi Desert in Inner Mongolia to prevent the desertification from spreading further.

The United Nations Convention to Combat Desertification (CCD- http://www.unccd.int/main.php) is an agreement to combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by international cooperation and partnership arrangements. To help publicize the Convention, 2006 has been declared "International Year of Deserts and Desertification".

Forest biotechnology

Gene, only a polymer consisting of DNA, has been dealt as one of the chemicals since Watson and Crick's hypothesis was proved. Although it is known that DNA itself starts the life phenomena, the study on DNA's cooperative activities and interactive results among final products - enzymes - by DNA is still in its infancy in all the plant species.

The biotechnology in forestry has a profound impact on all the areas of forest sciences, expecially useful to understand and manipulate the genetic make-up of plants. Tree molecular biology has advanced dramatically in recent years. Now genome sequences for model plants such as *Arabidopsis* and *Populus* were completed. Understanding of the genetic characters of all traits of plants is rapidly progress. Development and application of biotechnology tools are summarized as micropropagation by tissue culture, molecular marker applications, genomics and genetic modification of forest plants. In a broad sense, biotechnology includes *in vitro* propagation techniques, highly valuable in multiplication of rare and endangered plant genetic resources, and genetic transformation which leads to the production of new varieties.

The primary applied goal of *in vitro* culture of forest trees has always been mass clonal propagation. Micropropagation is used to create large numbers of individual clones or genotypes. Micropropagation represents an ideal way to conserve the endangered plants. Moreover, micropropagation is very important step for genetic transformation of plants. Advances in somatic embryogenesis have brought mass clonal propagation of the top commercial trees closer to reality, and efficient gene transfer systems have been developed for a number of conifers and hardwoods.

The development of specific molecular markers for tree species is very promising to detect genetic diversity, mating types, fingerprinting, and QTL mapping. These applications are becoming increasingly commercial in scope.

Genomics is the most rapidly expanding area of research fields in forest biotechnology including gene discovery. The comparative genomics and functional genomics can generate basic idea for forest tree genetic breeding to improve the tree quality, which is highly researched area in forest biotechnology.

Forest tree improvement is difficult by long generation times of trees. Genetic modification of forest tree is promising research field for broad applications of the forest biotechnology. Advances in the technology have been due to development of a range of *Agrobacterium*-mediated transformation techniques, along with appropriate tissue culture techniques. Rapid growth of tree by genetic modification can also focus on the production of raw wood materials. Lignin quantity and composition of wood can be affected by alteration of gene involved in the phenylpropanoid. Radical alterations in the quantity and quality of lignin in wood have been shown to be possible in softwoods and

hardwoods through identification of naturally occurring mutants, as well as by engineering the lignin biosynthetic pathway with transgenes.

Molecular breeding of tree is useful for production of arid, drought, and heavy metal-resistant trees in saline, frost and metal polluted zones of soil. Another application of biotechnology involves mitigating the greenhouse gases associated with global warming by carbon-sequestering plantations of transgenic trees. Biomass and bio-fuel production from trees will be increasingly utilized as energy source, as well as a carbon sink to help control global warming.

The potential environmental and social impacts of the release of transgenic trees have become an increasingly contentious issue that will require more attention if we are to use these technologies to their full advantage.

Timber demand of Korea

The economic evaluation in forest tree breeding (Fig. 1) is based on how much the society will demand the product, i.e., timber for furniture and house construction, pulp, fruit, or others from the target tree species. For instance, the wood for furniture will be used at least 10 years after the successful accomplishment of the breeding program. In some cases, we should wait for 50 to 60 years or more to harvest the plantation established. It is hard to predict the industrial demand for the timber of target species several decades later. This is why we need more inter-disciplinary cooperation for the fruitful breeding program.

In 2005, US$ 2,463 million was spent to import forest products and its 80% for timber including log, plywood board, and sawn wood. It is reported self-sufficiency for timber reached 8% in 2005. US$ 181 million (7%) was used to import non-timber forest products.

Reforestation of North Korea's Forest

Based on satellite information, KFRI reported in 2006 that forest of North Korea is 9,160,000 ha and it covers 74% of its territory. 1,630,000 ha, ca 18% of the total forest, needs immediate reforestation, which will prevent the forest from landslide and soil erosion and provide sound basis for agriculture, other industry and furthermore environment preservation.

Several planting events were held in Kaeseong Industrial Complex in 2005 and 2006. Between the same two years many NGO's provided seedlings and seeds to the North, including Korean white pine, chestnut, *Larix*, and etc.

Before providing seeds and seedling, it should be considered in depth what species, varieties and silvicultural technology are qualified to be delivered. At least 30 to 40 years later, it will be on the desk of serious discussion by our next generation of Korean people whether the species or varieties was chosen discreetly with the consideration for their future use and benefit or not.

STRATEGY OR SUGGESTIONS FOR THE NEW ERA OF TREE BREEDING

Diversification of breeding goals- New paradigm

Breeding goals have been mainly concerned with productivity (growth, fecundity, high yield of special substance, and etc.) and quality (straight stem, clear length, and etc.). However, it is recommended strongly to diversify the breeding goals in detail. Department of Forest Genetic Resources, KFRI, has good examples, such as research on phytoremediation and resistance to some pollutants.

As shown in Fig. 1, to set up the breeding goals, two aspects have been considered seriously; those are biological knowledge and economical prospect. However, as we observed many challenges mentioned above inside and outside forest tree breeding, one basic concept, i.e. demand in public welfare, should be added to this process as one valuable decision factor equivalent to the other two. Some suggestions or examples based on this hypothesis will be shown:

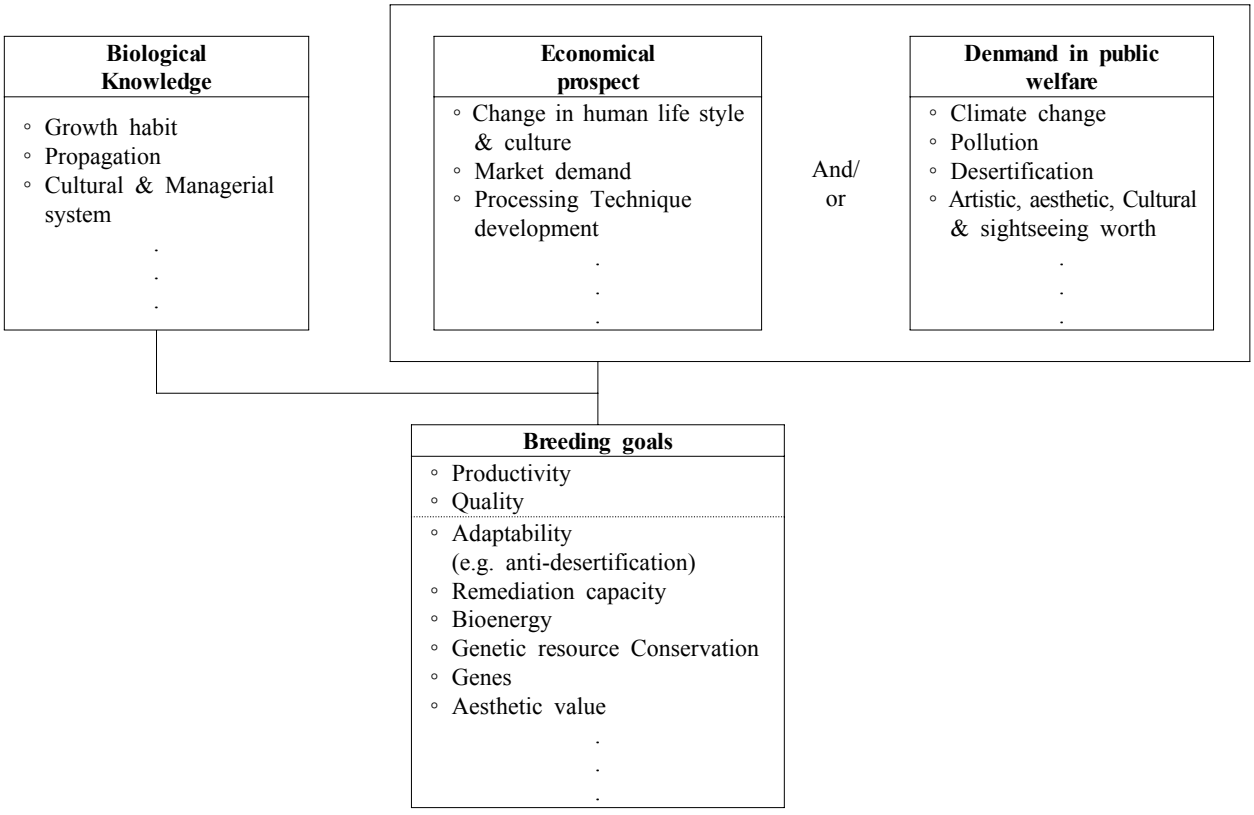

Fig. 1. What are the breeding goals and methods in tree breeding? How can we set up breeding goals? Goals are dependent on present and probable information on biological knowledge, economical prediction and demand in non-profitable, public welfare. Breeding methods, however, are completely dependent on biological aspects other than breeding goals.

"Demand in public welfare" is getting more and more important in the forest sector and so may be in forest tree breeding. Species or variety development of highly adaptable to ruined, polluted or desert land can be one of valuable breeding activities for Korean and international society. It may include the research of genes that are showing such activities.

Living organisms keep the planet habitable. Plants and bacteria carry out photosynthesis, which produces oxygen. Trees absorb carbon dioxide, which can help in the fight against global warming. The monetary value of goods and services provided by natural ecosystems (including gas regulation, waste treatment, and nutrient recycling) is estimated to amount to some 33 trillion dollars per year nearly twice the global production resulting from human activities (IUCN-http://www.iucn.org/themes/ssc/red_list_2004/Extinction_media_brief_2004.pdf). Many species are of immense value to humans as sources of food, medicines, fuel and building materials. Between 10,000 and 20,000 plant species are used in medicines worldwide. Currently about 100 million metric tons of aquatic organisms, including fishes, molluscs, and crustaceans, are taken from the wild every year and represent a vital contribution to world food security. The diversity of nature helps meet the recreational, emotional, cultural, spiritual and aesthetic needs of people. Korea Forest Service reported the non-economical benefit from forest was estimated about KW62 trillion in the fiscal year of 2005 and it will reach KW100 trillion in 2010.

As discussed in BACKGROUND above, the bioenergy demand is increasing and the Korea Government has a huge investment plan. Forest biomass is also quite promising as the energy source in North Korea. Therefore tree species or variety development for energy may be as one of examples of tree breeding goals and broaden the scope of forest tree breeding. About 200 thousand ha of

farmland was thought to be idle or unused upto 2004 and because of aging of farmers and FTA such acreage will be 300 thousand ha in the near future (Korea Rural Economic Institute-(http://www.krei.re.kr/issue/report_view.php?vKey=R508&vTop=1&vPage=1&vBid=r&vPage=1&vFind=&vSearch=). Trees may be a desirable choice for biomass production in this un-invested agricultural land. The new variety developed for this purpose should satisfy the requirements of UPOV.

Aesthetic or landscape value is considered as important as economic value of timber production. It may be said that flower variety establishment may belong to the area of horticulture. But woody and non-woody plants with beautiful flowers are so common in forest of our land. They are our priceless genetic resource which can bring high income to the nursery men and floricultural industry.

Little attention seems to be given to forest genetic resources conservation in Korea. There are some considerations to take advantage of seed orchards and progeny test plantations for gene conservation purpose. National arboretum also tries hard to keep the rare and endangered plants in its garden. Both endeavors, however, are not enough for the conservation of resources for our children. Breeding activities actually focus on the future rather than the present. Every activity in tree breeding should take firm stance and start, with the objectives of genetic resources conservation.

Gene study also needs much consideration. This may be related with any research, but above all with resistance, growth or specific substance. If concerned with research area, the objectives of this study will come together with those of genetic resources or biotechnology.

We are still in need of timber. Only about 8% of timber demand is supplied by domestic production. Ecologically and socially, pine and oak are thought to be possible, main target species to meet this need. Enough research data are not available for both species at the moment. Gene survey, provenance test covering the whole distribution area (even China and Japan), resistance to all kinds of hazards, and etc. should work together with every field of forest science including silviculture, ecology, management, utilization, and etc. This objective cannot be achieved without multi-disciplinary research.

Breeding procedure- Target species, methodology, and manpower

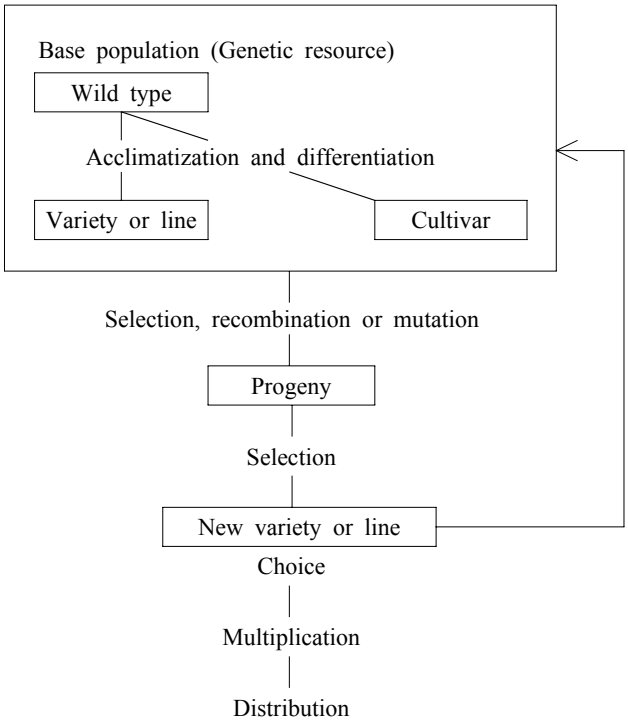

Fig. 2. General procedure of forest tree breeding. Quadrangle stands for tree population and letters stands for works that breeders are supposed to do for the next step or generation establishment.

Target species- Global

Fig. 2 shows the general procedure of tree breeding. In the uppermost quadrangle the base population is found. It is actually the genetic resource, which may include even the developed variety or line. Every work (the letter without quadrangle) can be repeated once or twice at that step and a population (the quadrangle) can be established accordingly. The size of each population is completely the breeders' choice.

A country, Korea which supplies almost all the timber demand with foreign products, should establish plantation in other countries. It is one way to pay what Korea owes to them. Korea was heavily dependent on foreign timber

for its industrialization. Also many an international agreement recommends that developed countries should practice afforestation in underdeveloped countries.

Korea should not limit target species to domestic ones. The base population can include the tree species in Indonesia, Malaysia, Vietnam, China, Mongolia, and etc.

Research methodology- Multidisciplinary

Generally every breeding project needs the important breeding activity at the first step, that is the activity under the base population in Fig. 2. The methods, traditionally, are; selection, introduction, hybridization, and mutation. The biotechnological method should be adopted widely. At this step the conventional breeding method will be more efficient with cooperative works of biotechnology and vice versa.

Research manpower- National and international network

There are a lot of tree breeding manpower in KFRI, colleges, and institutes. The network covering national and international scientists is recommended when it starts a new project. Some of foreign scientists can be members of breeding program whenever it aims at improving foreign tree species. The project can be consulted by famous researchers before it starts.

This network may provide good chances for the young scientists to communicate with experienced scientists.

Organizational considerations

It may not be included in this topic. However, to meet challenges and needs at the present and in the future, which are discussed in detail above, some systems should be considered for establishment carefully.

1. The administrative staff and system in KFS for effective management of forest genetic resources are not well equipped. These resources require national management and protection. Without investment both in manpower and budget, our next generation cannot enjoy the diversity of forest genetic resources as much as we do. It is also important to have a system to keep up with international trends as recommended by Bioversity International (http://www. bioversityinternational. org/) and CGIAR System-wide Genetic Resources Programme (http://www.sgrp.cgiar.org/).
2. The organization is necessary to carry out efficiently biological data collection, breeding, afforestation, management, and etc. in the forest of foreign countries. For example, in the afforestation of huge Indonesian forest, Korean officials and private companies do not have enough information and manpower. The system may be organized under KFRI for scientific approach to them.
3. The new technology should be practiced in forest tree breeding efficiently. That is 'forest biotechnology' in a broad sense. For the efficient use of this technology, a research organization as an independent unit under Department of Forest Genetic Resources, KFRI should be established. It can cooperate with other systems engaged in conventional tree breeding and shorten the breeding period. Furthermore, it will produce many results on genetic resources conservation, new variety, gene study, and etc.

Basic principles for new tree breeding

1. Attack the breeding project by multi-disciplinary approach in settlement of objectives, breeding methods, and etc.
2. Broaden the target plant species, whether herbaceous or woody and whether foreign or domestic.
3. Consider and satisfy the demand for forest tree breeding not only from domestic but also from abroad.
4. Start the breeding program, only after it is well grounded on genetic resource conservation.
5. Assume the products (i.e., variety, technique, gene, and etc.) to be obtained as goods.
6. Let scientists share the research results with others including young scientists.

EXAMPLES OF SOME PROJECTS

Seed Sources and Nursery Technology Development Project by KOICA, Korea Forest Service, and Indonesia Ministry of Forestry

This project, cooperative one by three organizations with the technical support of KFRI, started in July, 2005 and ended in December, 2007. This is the first, systematic foreign tree breeding project by Korean people.

Its objectives are:

- To improve the capacity of Indonesian forestry human resources.
- To improve land forest rehabilitation technology in Indonesia by sharing Korean experiences and knowledge on seed sources development and nursery management.
- To contribute to the social and economic development of Indonesia by enhancing the economic value of forest resources.
- To strengthen the relationship and cooperation between two countries.

Except construction, training and equipment, achievement related with tree breeding will be shown here. Main works are selection of mother trees and establishment of progeny test plantation.

Number of species: 113

Selected plus trees: 850 (All are not available for seed production and/or clone; Mother trees- 450, Seed exploration- 51, and Clonal exploration- 232)

Important species are *Peronema canescens*, *Alstonia spectabilis*, *Intsia bijuga*, *Agathis lorantiolia*, *Maeopsis eminii*, *Shorea leprosula*, *Acacia mangium*, *Eucalyptus pellita*, *Tectona grandis*, and etc.

Progeny test plantation:

Rumpin site-	Demonstration plot	5.65 ha
	Other	3.38 ha
Jasinga site-	Demonstration plot	14.6 ha
	Progeny test	53.6 ha
	Other	13.48 ha
Sotek site-	Demonstration plot	14.6 ha
	Progeny test	53.6 ha
	Other	10.4 ha

This project was managed by one Korean forest official, Mr. Song Hee Nam, who did not have much experience in tree breeding research or works. But he worked with several Indonesian scientists engaged in nursery and tree breeding. The experimental plots were established successfully and the information of progeny test will be used for seed orchard establishment. Seed orchard will be a seed source of reforestation by Korean and Indonesian companies in Indonesia in the near future.

The success of this project suggests a high possibility of Korean tree breeding technology to support other countries, especially developing and underdeveloped countries. Such project will provide an opportunity that breeding scientists can practice their capacity and eventually obtain much information about foreign tree species.

Fig. 3. Nursery for seedling production of progeny test.

Fig. 4. Progeny test plantation in Sotek.

Non-timber Forest Products R&D Center (NTFP) at the College of Forest and Environmental Sciences, Kangwon National University

In November 2006, NTFP R&D Center was established by KFS research fund. It adopts multi-disciplinary research scheme and focuses on *Codonopsis lanceolata* (Deodeok in Korean), *Panax ginseng*, and *Ulmus davidiana* var. *japonica* (elm). It has four research teams; that is breeding and cultivation, biotechnology for specific gene study and mass-propagation of specific genotype, substance extraction and component analysis, and animal test for commercial products. For the last task the professors of Medical College joined the Center.

The one of the expected results about *Codonopsis lanceolata* is a colored one - a variety showing red or gray peel. It is more expensive by 50% to 100% than the usual, white one in the market. We do not have information on color expression and substance composition. The variety may be fixed or developed by conventional selection or hybridization breeding method. The molecular study on gene itself or its expression (hopefully) and the mass-propagation of the variety will be carried out. Chemical component analysis will be done and differences can be observed among varieties. And a correlation study is possible between chemical composition and color performance. Obtained extracts will be used to test anti-oxidation, anti-cancer, whitening effect in cosmetics, and etc.

CONCLUSION

Social and scientific changes in international and national society inside and outside forest tree breeding of Korea are reviewed. They include global warming, desertification, pollution, biodiversity, bioenergy, plant variety protection, biotechnology, timber demand, and reforestation in North Korea.

Based on challenges, diversified breeding goals, globalization of breeding target species, multidisciplinary research approach, manpower networking, establishment of new administrative and research units in KFS and KFRI were proposed.

Principles for new tree breeding strategy were suggested. They are 1) multi-disciplinary approach in settlement of objectives, breeding methods, and etc., 2) expansion of target tree species, 3) fulfillment of both domestic and international demand for forest tree breeding, 4) establishment of breeding program well grounded on genetic resource conservation, 5) acknowledgement of breeding products (i.e., variety, technique, gene, and etc.) as goods, and 6) provision of more research opportunities for young scientists.

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