Hardwood Plantation Project for Pulpwood in Laos

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Good afternoon, ladies and gentlemen. My name is Kazuya Ito. I am a general manager at Oji Paper's Forestry Research Institute. Thank you for giving me this opportunity to present our plantation activities under the title "Hardwood Plantation Project for Pulpwood in Laos."

Today, I will present you with four topics. The first is an outline of Oji Paper's plantation projects. I'll explain plantation projects throughout the world and also the characteristics of eucalyptus and acacia as pulpwood. The second topic is related to concerns about the effect of hardwood plantation on the environment. Some people here are concerned about water consumption and nutrient usage by fast-growing trees like eucalyptus, and I will also mention some effects on biodiversity. The third topic is an introduction of the plantation project in Laos. The last topic concerns issues with and approaches to expanding hardwood plantation in Laos, from the viewpoint of the breeding and development of silviculture.

This figure shows our overseas plantation projects. We have eight chip export businesses right here, and also three pulpwood production projects. We prefer eucalyptus as pulpwood. The SPFL business is located in the southern part of South Island in New Zealand, a very cold place. In winter, temperatures are as low as -10^{o}C. *E. nitens* can still grow. Also, we have three plantation projects in Australia — APFL, GPFL, and EPFL. These are in temperate regions. We have planted *E. globulus*. This is the best species of eucalyptus as hardwood for pulp. Also, we have another four projects in areas including Southeast Asia. We have planted hybrid clones of acacia in Vietnam. This project here, QPFL, has started to plant *Eucalyptus camaldulensis* and *Acacia mangium,* but both species cannot grow very well. So we have changed our mind and planted clones of a hybrid of *Acacia mangium* and *A. auriculiformis*. Also, we have included some acacia in the last project shown in the table, LPFL. We have planted clones of eucalyptus hybrids and acacia hybrids. Our target is 300,000 hectares of plantation by 2010. If these projects come to an end, we have already achieved 220,000 hectares, but we still need 80,000 hectares to meet our goal.

I will show you the characteristics of eucalyptus used as pulp. There are several species suitable for tropical/subtropical regions. Two species, *urophylla* and *grandis,* are very popular in Brazil. Brazil was the first country in the world to establish eucalypt plantations. For temperate regions, we prefer *globulus,* and we have also imported some natural species of *regnans, delegatensis,* and *obliqua* from Tasmania.

I will also explain the advantages of eucalyptus. It grows quickly and has a higher basic density, with more than 400 kg per cubic meter; also, eucalyptus has a straight stem and characteristics of self-pruning. Self-pruning means that the lower branches fall off naturally. This is very good for us at harvest. But there are some disadvantages to eucalyptus. Eucalyptus needs intensive weeding, especially in the early stages of growth. If weeding is not done properly in the early stages, the rate of growth is cut in half. Another disadvantage of eucalyptus is that fewer species can adapt to the tropics. Therefore, we have selected acacia as the other target species for pulp production in the tropics.

Acacia seems to be a newcomer to our industry. Fewer species are used for pulp production only because of acacia's short history of utilization for this purpose. Acacia has the great advantage of fixing nitrogen in the air. In Vietnam, QPFL doesn't use nitrogen as a fertilizer. Also, acacia can compete with weeds. Even if we do not weed properly, Acacia can grow quickly. On the other hand, acacia is high in fatty acids, which causes some problems when making paper.

This slide shows the characteristics of species during the digestion process. The horizontal axis shows ease of cooking to produce pulp from chips. A lower value means it is easier to cook. The vertical axis shows the pulp yield. The analyzed samples have been classified into four categories. Numbers 1 and 2 are *globulus* from Australia or Chile, classified into category I, which has better digestibility and a higher pulp yield. In comparison with *globulus, camaldulensis,* numbers 6, 7, and 8, falls into category IV. This group is somewhat difficult to cook and has a lower pulp yield. The acacia, *mangium* from Papua New Guinea and *auriculiformis* from Vietnam, are classified as category III, which has a higher pulp yield but lower digestibility. We have planted both eucalypt and acacia in Southeast Asia. It is difficult to select species for plantation in Southeast Asia, including Laos, because we must base the decision on several considerations, including ease of cocking, pulp yield, ease of making paper, growth habitats, and so on.

There are three major concerns to consider as we enlarge our plantation area. Firstly, as eucalyptus can grow quickly and produce more biomass material, it may utilize more water, causing water depletion and related problems. Secondly, as eucalyptus may absorb more nutrients from the land, it may create wastelands with low soil fertility. Also, large-scale plantation may affect biodiversity. In spite of these concerns, eucalyptus plantation has been expanding throughout the world. Here are some reasons: As there are many species of eucalyptus, suitable species can be selected for target areas with varying conditions. Eucalyptus can grow in wastelands with low soil fertility. Also, eucalyptus wood is versatile and can be utilized for pulp, construction, fuel, and other uses.

Although there have been issues with the utilization of water by eucalypt throughout the world, many of them have been settled scientifically. Let me introduce some figures related to efficient water usage, according to FAO. This figure shows water use efficiency, including crops. Eucalyptus can use 510 liters of water to produce one kilogram of biomass. Eucalyptus can use water very efficiently. But because eucalyptus can so quickly produce biomass, it requires large volumes of water. If eucalyptus is to be planted in a low-rainfall area, say, less than 500 millimeters per year, care should be taken to avoid water deficiency in that area. I will show you a case study of our plantation project in Laos, very briefly. The average rainfall is 1,750 millimeters. The growth rate is 12.5 bone dry tons per hectare per year. Water required is less than 10,000 cubic meters per hectare per year. Recharge by rainfall is more than 10,000 cubic meters per hectare per year. This is enough for the production of eucalypt. So there seems to be no concern about water efficiency in regard to eucalypt plantation in Laos.

Let me introduce sustainable plantation in Brazil. Cenibra, our sister company in Brazil, was established in 1973 to plant eucalyptus for pulp production. Their plantation area is 137,000 hectare so far. The target species are mainly clones of a eucalypt hybrid of *urophylla* and *grandis*. Annual rainfall is 1,100 to 1,300 mm. Annual mean temperature is 21^{o}–25^{o}C. The rotation cycle is seven years, on average. Currently, their plantation area is coming into its fifth or sixth rotation cycle. The growth rate is increasing. At the moment, 40 cubic meters per hectare per year may be the highest figure in the world.

I will give you other data on the consumption of water by eucalypt plantations at Scott River, in Western Australia. It is located 250 kilometers south of Perth. Annual rainfall is 1,100 millimeters. The planted species is *globulus*. In this area, plantations of *globulus* were started in 1996 and thinned and fertilized in 1998. Researchers have surveyed the water deficit in the soil since late 1998. This figure shows the soil water deficit. The dotted line represents soil without fertilizer. Low-stocked, medium, and unthinned comprise 300, 600, and 1,200 trees per hectare, respectively. No fertilizer means that growth is not so good. There are significant seasonal variations. This one here is in the dry period, summer. The deficit gradually expanded toward the end of rotation cycle, but soon after harvest in 2006, the water level recovered quickly. So there seems to be less concern about water deficits in areas with more than 1,000 millimeters of rainfall.

The second concern is the removal of nutrients from the land as a result of eucalypt plantation. As shown in the table, eucalyptus utilizes fewer nutrients per unit weight of biomass products in comparison with most crops, such as paddy rice and maize. In a seven-year rotation, 77 kg of nitrogen, 7 kg of phosphate, and 84 kg of potassium may be removed at harvest. At least the same amount of nutrients should be fertilized for one rotation. We should sustain soil fertility. In our plantation projects throughout the world, we apply fertilizer several times per rotation cycle.

Our last concern is related to effects of hardwood plantation on biodiversity. In this slide, I want to emphasize that not only eucalyptus but almost all crops that are not native to Laos or other countries may have adverse effects on local biodiversity. Uncontrolled invasion by introduced species may have negative impacts on native plants and animals in the area. Even if eucalypt seeds are dispersed from plantation areas naturally, they cannot survive in densely vegetated areas like

Laos, as they need light to grow. This shows that there is not much concern about eucalypt plantation in Laos. Also, Oji observes the laws and attempts to produce as much wood as possible in a limited space, thus maintaining or increasing the level of biodiversity in Laos.

Lao Plantation Forest Company, LPFL, was founded in 2005 as a joint venture with the government of Laos. The government's share is 15%. On the Japanese side, we have 11 companies involved in this plantation scheme. LPFL creates hardwood plantations for pulpwood, with rotation cycles of seven years. The target site is degraded forestland or barren land. The species for plantation are eucalyptus and acacia. Also, we promote clonal plantation to improve the productivity of the plantation area.

In 2007, we changed our plan to plant both eucalyptus and acacia. The planting ratio is around fifty-fifty. The area for acacia is expanding year by year, expected to reach about 7,000 out of about 18,000 hectares by the end of 2008. We will reach 25,000 hectares of eucalyptus and acacia in Laos by the end of 2009.

Our predecessor, BGA, a New Zealand-based company, planted only *Eucalyptus camaldulensis*. This is one of best clones of camaldulensis, BGA25. Because BGA25 is susceptible to some leaf diseases, we have conducted several trials to obtain new clones. K7 was originally imported from Thailand and has performed much better than BGA25.

K7 is a hybrid clone of *Eucalyptus deglupta* and *E. camaldulensis. E. camaldulensis*, which originated in Australia, is suitable for tropical and subtropical areas, drought tolerant but susceptible to leaf diseases in Thailand and also in Laos. Another species, *E. deglupta*, naturally originated in the northern part of Australia, Papua New Guinea, and Indonesia. This species is suitable for tropical areas and grows very quickly, but its density is very low, maybe 300-something kilograms per cubic meter. This figure shows the wood quality of K7. The basic density is 490 kilograms per cubic meter, which is lower than *camaldulensis* imported from Vietnam, but other characteristics are the same as *camaldulensis*. Thus, K7 has turned out to be our main eucalyptus clone.

We have imported several hybrid clones of acacia from the subsidiary company, QPFL, in Vietnam. They have performed well so far. The average height was around 10 meters after two years. Although we do not have any data on older acacia, growth at age two was right on the growth curve, which was taken from the data collected at better sites in Vietnam. Growth of hybrid clones is anticipated to be good in Laos.

Let me briefly talk about the improvement of acacia hybrid clones in Vietnam. Though growth performance improved greatly after the introduction of hybrid clones of acacia, we had a problem of lower basic density, shown by the pink triangle, very close to 400 kilograms per cubic meter.

Therefore, we have selected superior trees with good performance both in growth and in wood quality. We obtained samples from all of the selected trees and analyzed them in our pulp and paper research laboratory. The red squares in this figure show the basic density of selected trees. They are heavier than the original clone by 10%–20% and digest more easily than another LAC2, which encompasses acacia trees imported from several countries.

Efforts are being made to address a couple of issues related to advancing hardwood plantation in Laos. The first is improving the productivity of the plantation. The promotion of clonal forests seems to be the appropriate solution to this issue.

Cenibra has a long history of clonal plantation. As I mentioned before, their plantation is in its fifth or sixth cycle. Clonal plantation started in 1990. At this stage, 10% of their area was planted with clones. They used clones mainly of a hybrid of *urophylla* and *grandis,* which grows very quickly in Brazil. The clonal plantation area has increased year by year. They have been planting only clones since 2001.

This figure shows the improvement of the growth rate. Mean annual increment (MAI) at harvest in 1990 was 23 cubic meters per hectare per year. The plantation harvested in 1990 was planted from seedlings in 1983. The plantation harvested in 2007 was mainly clonal. MAI grew to 40 cubic meters per hectare per year, an almost 70% increase. Thus, clonal plantation is a very powerful tool for increasing productivity and became very popular for both eucalyptus and acacia.

I will explain the process of clonal plantation with newly acquired clones. First of all, we must acquire clones. The quickest way to do this is to acquire them from other organizations. Another way, which takes a bit longer, is to select trees at plantation and hybridize them to get the new clone. During the mass propagation of clones, we must assess the growth performance of the clone. About half of a rotation cycle is required to assess growth performance. So it takes 3–5 years to start commercial planting with newly acquired clones.

The second issue is the threat of pests and diseases. Production loss by pests and diseases may be offset by expansion of the plantation area, especially in clonal forests. There may be less genetic variation compared with plantation from seeds, so we should develop as many new clones as possible.

I will explain the present situation regarding clones of eucalyptus and acacia in Laos. For eucalyptus, we have only one clone, K7. It grows very quickly and is very tolerant of pests and diseases, but we have only one clone. For acacia, several clones have been imported from QPFL. They have performed well so far, but we still need other clones.

This figure shows the acquisition of new eucalyptus clones. In 2006, we brought hybrid clones of *urophylla* and *grandis* from China. These three clones are commercial clones from CPFL, a subsidiary in the south of China. Trials are still being conducted. We do not have concrete results so far. Also, we have conducted several trials with new clones from China and Thailand. We obtained three from Thailand as well as some natural hybrids of *pellita* and *brassiana* from Vietnam in 2009.

As I mentioned above, the decision to use commercial clones from China has not been made yet. DH3213 from China performed very well in the first year, but in the second year, it got a disease. It lost many leaves, in contrast to K7, which is very healthy. Hybrids from China seem to be unsuitable for Laos. Thus, acquired plants should be carefully evaluated for adaptability to the site, especially in higher-rainfall regions.

We have other good candidates for new clones. The Research Center for Forest Tree Improvement, located in Vietnam, obtained many clones of a natural hybrid of *pellita* and *brassiana*. Researchers selected higher-performance clones and have already conducted trials in Vietnam. This figure shows the rainfall pattern in Laos and Vietnam. The quantity of rainfall is different, but the pattern is quite similar in both countries, as are edaphic conditions and mean annual temperature. These natural hybrid clones should perform well in Laos.

We have established a species trial to get more suitable species for pulp. The survival rates of *brassiana* and *camaldulensis* are relatively higher than *pellita*, but *pellita* grows better, as the figure clearly shows. As *pellita* can grow even after four years of planting, hybrids of *pellita* and *brassiana* or *camaldulensis* should perform well in Laos.

Let me explain how to create superior hybrids of *camaldulensis* and *pellita*. We have already selected superior clones of *camaldulensis*, shown in this photograph. This is the selected tree; the height is over 23 meters, and the diameter at chest height is about 20 centimeters, which makes it a good clone. Now we are making grafted clones, and then we will add some chemicals to promote flowering. After flowering, we will do some hybridization work with *pellita* to select good clones from the offspring of the hybrid seeds.

This photograph shows the performance of a natural hybrid of *pellita* and *brassiana*, selected in Indonesia. These logs were taken from five-year-old trees. You can see that the growth performance of the hybrid is much better than that of the original species.

We have done some trials with acacia hybrid clones from QPFL. As these clones have performed well so far, we have decided to expand those areas of hybrid. In 2008, we have already planted over 1,000 hectares. Also in 2008, we have obtained other hybrid clones and clones of *auriculiformis* from QPFL and the Forestry Science Institute of Vietnam for testing.

Matching clones with sites is a very important factor in maximizing pulpwood productivity per area unit. Our plantation area in Laos is roughly separated into two types — loamy and sandy.

This figure shows the growth performance of K7 and *Acacia mangium* in both soil types. While K7 grows better at sandy sites, *Acacia mangium* grows better at loamy sites.

The third issue is the sustainability of soil nutrition. Generally speaking, our target sites are less rich in nutrients, and there are some symptoms of nutrient disorder, especially in boron.

This table shows the macro-element level of leaves, which reflects the soil nutrient level. There are adequate levels of nitrogen, phosphate, and potassium. Also, there are shortages of micro-elements in zinc and boron.

The figure shows boron deficiency in eucalyptus. A–C are for *grandis urophylla* hybrids. D–G are for K7. There are changes in pigmentation in the young leaves shown in A, D, and F; developing leaves may be malformed, with missing sectors, as shown in B. Boron deficiency severely impairs the growth of the shoot tip and causes stem forking and twisting due to slowed growth.

This photograph shows you some symptoms in an acacia hybrid plant. Yellowing extends from the edge over the whole blade, and developing leaves are malformed, with missing sectors. Shoot tips are likely to die, and this may cause multiple shoots. We have established several trials to elucidate adequate levels of macro- and micronutrients.

The last issue is the challenge of plantation in areas with severe conditions. There are a lot of waterlogged sites along Mekong and major roads. We have started to plant trees in the waterlogged sites due to the shortage of land for hardwood plantation in Laos. In Laos, the main rainy season starts in May and ends in September. The risky period for waterlogged areas is from July to September. As the waterlogged areas are basically very flat, it is very easy to conduct plantation activities such as preparation, planting, weeding, and fertilizing; however, we expect disturbed growth.

We have conducted a soil survey in the waterlogged area. There are some layers that are rich in iron or clay, which may cause trouble for water drainage. Several measures should be undertaken. We should select species or clones that are tolerant of a shortage of oxygen in the soil and also undertake civil engineering projects, such as building water channels to improve drainage.

This is my last slide, which shows another example of planting materials for a waterlogged site. *Acacia peregrinalis,* which is quite new to the pulp industry, and K7 can survive under waterlogged conditions. Though we have planted *Acacia crassicarpa,* which is very popular in waterlogged areas in Indonesia, almost all of them were missed. The provenance of *A. crassicarpa* may be important. Growth performance should be carefully monitored for the next 2–3 years. It is very risky but challenging.

Thank you very much for your attention.

Questions and Answers

(Question) Thank you very much for your explanation of eucalyptus clones. I am sure that you made good clones. I do not know the history of disturbance in Laos, but hedging against pests and diseases is very important. I am concerned about the risk of forest fires and the need to improve our methods of dealing with them. What is your opinion?

(Kazuya Ito) As we have not had many problems with fires in Laos, I have not considered developing clones with a tolerance to forest fire. Generally speaking, Eucalyptus can tolerate forest fire. Even if a eucalyptus plantation is damaged by fire, significant numbers of eucalyptus can survive and grow again. It is very difficult to obtain clones tolerant to fire.

(Question): In the case of pine trees, I assume tolerance to forest fire is low.

(Kazuya Ito) In the case of Australia, native forests of eucalyptus have come in contact with many fires, and occasionally big ones. But plantations do not get big fires because there is less fuel on the ground.

(Question) Thank you very much for the informative talk. You said that tree plantation projects in Laos are facing some criticism regarding the environment, and you explained the major concerns. I totally agree with your ideas, but as I understand it, most of the concerns are problems of scale. As you know, in Asian countries, the landscape is very small; roads are narrow and houses are tiny. If large areas of land are occupied, that may be of great concern to local people and their local government. Standardized management should be more economic; I understand that. But now may be the time for private sectors to decentralize this management because, in the case of Thailand, most eucalyptus plantations are contract-based with its whole partners. This would mean direct management of plantations by the private sectors. I sincerely respect your efforts in Laos, but this may be something to consider. What do you think?

(Kazuya Ito) This is a tough question for me. This slide shows our plantation sites, which are very scattered. It is true that we don’t have large-scale lands for plantation, except in Brazil. In Brazil, we have a large plantation area around a pulp mill. In all of our other plantation projects around the world, our plantation sites are on a very small scale. Now, we will have planted 18,000 hectares in Laos by the end of this year. We have around 200 plantation sites, so each site is around 80 hectares. Also, we have already put some farmer plantation schemes into action.

(Question) So 80 hectares is not so large. Does it incur high management costs for the company?

(Kazuya Ito) Yes.

(Question) I see. But you are still promoting it.

(Kazuya Ito) Yes. It is very difficult to get large areas of land in Laos or other countries, except Brazil.

(Question) Thank you.

(Question) I have a question about your arguments about water availability under the plantation system. There is an idea that in any ecosystem, the structure and function should go together, so that the main arguments for plantation are being counted as far as the functionality perform the same thing as natural forest. In terms of water, I am curious, because the data you showed is based on water use within your plantation. Regarding water that is coming out of the system or water availability outside your forests, what is the situation there? Is less water available now in surrounding areas, compared to when there was original vegetation or original land use?

(Kazuya Ito) This is another tough question. At this stage, we do not have enough information on water consumption in large plantation areas. I'll talk to you later, one on one.

(Question) The reason I asked the question is that one of the basic things that natural forests are supposed to do is soak up water and release it gradually or use it in other places. What I want to know is whether plantation systems do the same thing.

Hardwood Plantation Project for Pulpwood in Laos

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1. Overseas plantation projects in Oji Paper

	Country	Region	Company	Species	Target (ha)	Planted*1 (ha)	Harvest cycle (years)
Chip export	New Zealand	South Island	SPFL	E. nitens	10,000	10,083	12
	Australia	Western australia	APFL	E. globulus	24,000	23,696	10
	Australia	Victoria	GPFL	〃	6,500	6,548	10
	〃	〃	EPFL	〃	2,800	2,864	10
	Vietnam	Binh Dinh Province	QPFL	A. mangium x A. auriculiformis	13,000	11,056	7
	China	Guangxi	CPFL	E. urophylla x E. grandis	6,500	6,361	6
	〃	Guangdong	KPFL	〃	25,000	23,424	5
	Laos	Cetral Laos	LPFL	Eucalyptus hybrids Acacia hybrids	50,000	18,600	7
pulp production	Brazil	Minas Gerais	CENIBRA*2	E. urophylla x E. grandis	43,450	57,155	7
	New Zealand	North Island	PANPAC	Radiata pine	30,000	32,765	30
	Canada	Alberta	AFPI	Populus	7,500	1,971	～25
Total					218,750	194,523	
Target					300,000		

*1 : Tree plnatation areas are as of the end of December 2008 for CPFL, KPFL, Cenibra and AFPI, and as of the end of March 2009 for the others.

*2 : The total target area and planted area for CNB wrere pro-rated by our investment percentage(CNB:39.84%).

Clonal plantation

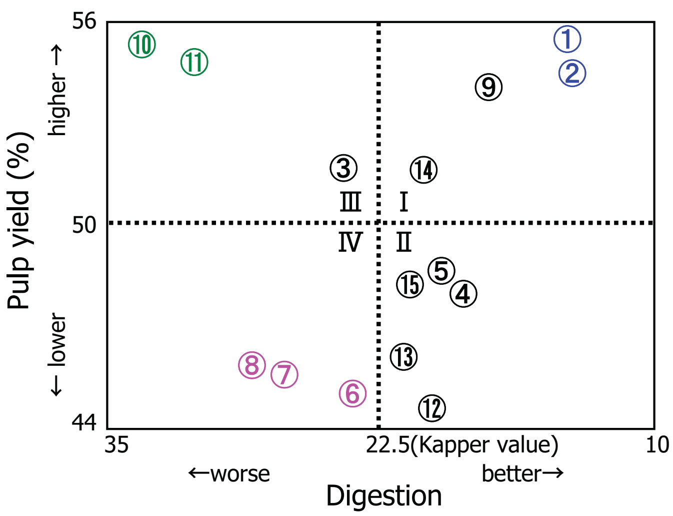
1) Characteristics of Eucalyptus for pulp

Eucalyptus		
Main species for pulpwood	Tropical / Subtropical	urophylla, grandis, camaldulensis, dunnii, saligna
	Temperate	globulus, regnans, delegatensis, obliqua, nitens
Characteristics		Advantage: better growth, heavier basic density (>400kg/m3), straight stem, self pruning Disadvantage: intense weeding in the early stage, less species for tropics

2) Characteristics of Acacia for pulp

Acacia		
Main species for pulpwood	Tropical / Subtropical	mangium, auriculiformis, crassicarpa
	Temperate	meransii
Characteristics		Advantage: better growth, nitrogen fixation, less weeding Disadvantage: less heavier basic density than Eucalyptus, large crown, high fatty acids content, less usage for pulpwood

3) Characteristics of species in digestion process



・LE3: ①E.globulus (Australia),②E.globulus (Chile), ③,④ E.grandis (South Africa)
・LE2: ⑤Natural Eucalyptus (Australia)
・LE1: ⑥E.camaldulensis (Thailand),⑦E.camaldulensis (Vietnam)、⑧Eucalyptus (China)
・LAC1: ⑨A.mearnsii (South Africa)
・LAC2: ⑩A.mangium (Papua New Guinea)、⑪A.auricuriformis (Vietnam)

2. Concerns on expansion of plantations

Concerns

- As Eucalyptus can grow fast and produce more biomass materials, it utilizes more water and may cause water depletion and other related problems.
- As Eucalyptus may absorb more nutrition from the land, it may increase waste lands with low soil fertility.
- Large plantation may affect biodiversity.

Characteristics of Eucalyptus

- As there are many species in Eucalyptus, suitable species can be selected for target areas with different conditions.
- Eucalyptus can grow on waste lands with low soil fertility.
- Logs of eucalypt are versatile materials for pulp, construction, fuel and other uses.

Expansion of Eucalyptus plantation in the world

1)-① Does Eucalyptus utilize excessive water ?

- Eucalyptus utilizes less water per unit weight of biomass
- Volume of water is dependent on volume of biomass produced

Water use by plants through evapotranspiration

Species	Water use per total biomass (litres/kg)	Harvest index	Water use per harvested biomass (litres/kg)
Coffee/Banana	3,200	0.25	800
Sunflower	2,400	0.25	600
Paddy rice	2,000	0.30	600
Pine	1,538	0.65	1,000
Soybean	1,430	0.35	500
Acacia	1,323	0.65	860
White potato	1,000	0.60	600
Sofghum	1,000	0.25	250
Albizia	967	0.60	580
Eucalyptus	785	0.65	510
Finger Millet	592	0.40	240

Source: FAO(1993)

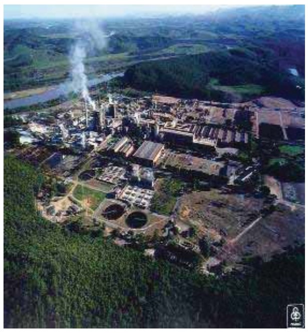
* Much of water taken by plants are then transpirated into the air, thus the water circulation follows (good for the environment).

Ex): LPFL Rainfall 1,750mm(include S-LPFL)、MAI 25(12.5 BDt/ha/year)
Water required* 12.5x785 = 9,812.5m^3/ha/year
Recharge (Rain) 100x100x1.75 = 17,500.0m^3/ha/year

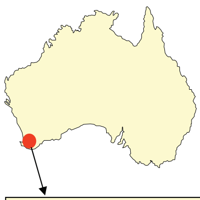
② Sustainable plantation of Eucalypt in Brazil

Cenibra: Established in 1973 & owned by Japan Brazil Pulp & Paper Resources Development (Oji's share:39.84%)

Plantation area	137,000ha
Target species	Eucalyptus(mainly hybrid)
Annual rainfall	1,100～1,300 mm
Annual mean temperature	21～25℃
Rotation cycle	seven years in average
Growth rate	40m^3/ha/year (increasing)

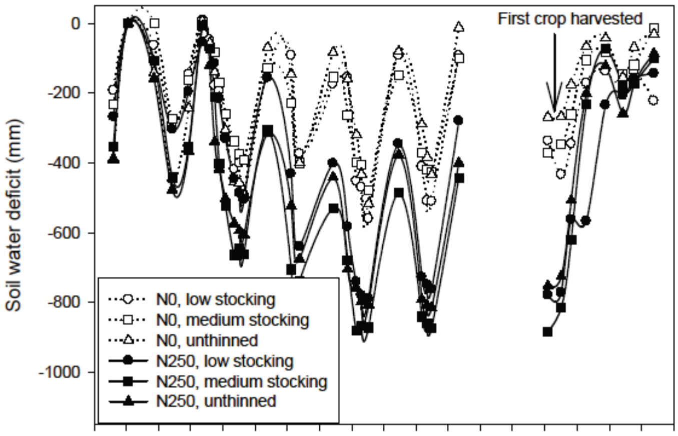


③ Consumption of water by eucalypt plantation in WA



Scott river
Annual rainfall: 1,100mm
Species: E.globulus

Planted in 1996 and thinned & fertilized in 1998



Soil moisture is declined gradually in accordance with growth period. But condition of soil moisture is restored soon after harvest of trees. It may be less concern about soil moisture at the area with certain level of annual precipitation.

2) Does Eucalyptus utilize more nutrients ?

- Eucalyptus utilizes less nutrients per unit weight of biomass
- Although Eucalyptus removes nutrients at every harvest, plantation sites are fertilized enough to conduct sustainable forestry.

Uptake and removal at harvest of nutrients for plants

	Uptake			Removal		
	N	P	K	N	P	K
	(kg/ha/Yr)			(kg/ha/Yr)		
Paddy rice	110	24	170	33	7	51
Maize	160	30	150	40	8	38
Sorghum	120	21	95	30	5	24
White potato	80	14	120	50	11	80
Soybean	−190	20	65	−135	13	32
Sugarcane	150	30	210	67	12	115
Coffee	110	9	120	40	3	48
Rubber	312	33	163	16	3	12
Banana	130	12	450	45	6	130
Eucalyptus	76	6	43	11	1	12
Acacia	−307	10	110	−50	3	18

Source: FAO(1993)

If rotation is seven years, 77kg of N, 7kg of P and 84kg of K may be removed at harvest. At least the same amounts of nutrients should be fertilized for one rotation.

3)Does Eucalyptus have adverse effects on biodiversity ?

Not only Eucalyptus but also almost all of crops are exotic. They may have some adverse effects on biodiversity.

1. Concern on biodiversity is invasion of introduced species by self-propagation to cause negative impacts on native plants and animals in the area. If eucalypt seeds disperse from plantation area, they can not survive in densely vegetated areas. ⇒Not much concerns
2. Large plantation of any species including crops may have some adverse effects on biodiversity.
3. Oji observe the laws and attempts to produce as much wood as possible in limited space, thus allowing the level of biodiversity to stay the same or increase in other types of lands.

3. Outlines of hardwood plantation in Laos

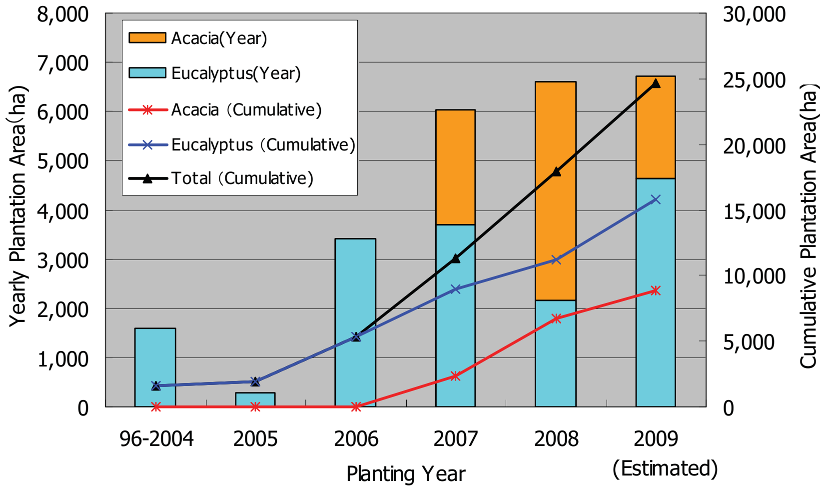
Lao Plantation Forest Company (LPFL) has been founded in 2005 under the joint venture scheme with Laos government.

LPFL
- 15% Government of Laos
- 85% Oji Lao Plantation Holdings
  - Oji Paper(73.33%), Kokusai Pulp & Paper(5%), Shueisha(5%), Mitsui S.K.Lines(5%), Senshukai(5%), Recruit(5%), others(5 companies, 1.67%)

1. Hardwood plantation for pulpwood with rotation cycle of seven years.
2. Target site: degraded forest land or barren land
3. Species for plantation: Eucalyptus & Acacia
4. Clonal plantation

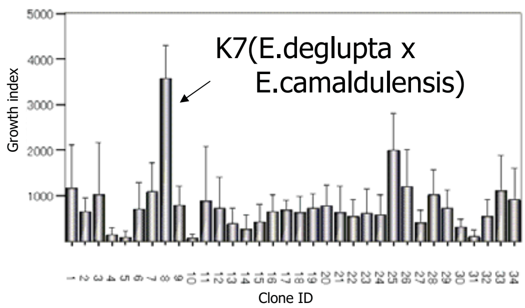
1) Plantation area & species

Original plan：Eucalyptus 100% ⇒ 2007～ Eucalyptus : Acacia = 50:50
･Acacia can grow fast just like K7(eucalypt best clone in Laos)
･Slopes/long distance：Acacia



2)-① Planting clones in Eucalyptus

A hybrid clone K7 performed better.



Growth performance in clonal trials
(mainly E.camaldulensis) at age 4 years

Commercial plantations
Left: E.camaldulensis best clone
Right: E.hybrid clone

② Analysis for wood properties in K7

K7=E.deglupta x E.camaldulensis

Species	Origin	Characteristics
E.camaldulensis	Australia	suitable for tropical & subtropical area, drought tolerant
E.deglupta	Papua New Guiana	suitable for tropical area, fast growth, light basic density, construction wood

Wood quality of K7 similar to LE1 from Vietnam

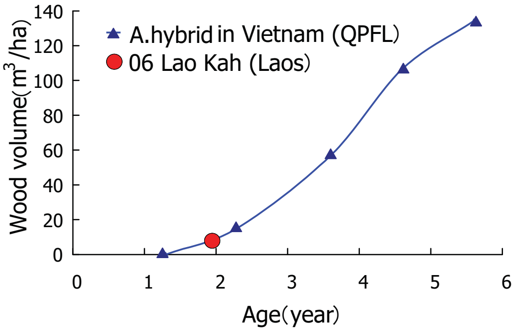
	Evaluation	Reference
	K7	LE1 E.camaldulensis (Vietnam, QPFL)
Basic density(Kg/m^3)	490	511
Length of fiber(mm)	0.62	0.59
Width of fiber (μm)	15.0	14.7
Thickness of fiber (μm)	4.5	4.4

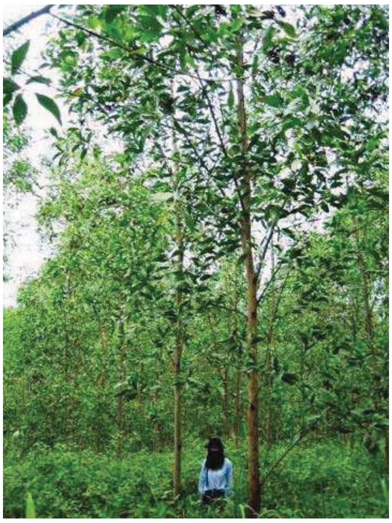
3)-① Planting clones in Acacia

Acacia hybrid clones (QPFL) performed better.

・Average height： 9.7m

Enlargement of the area

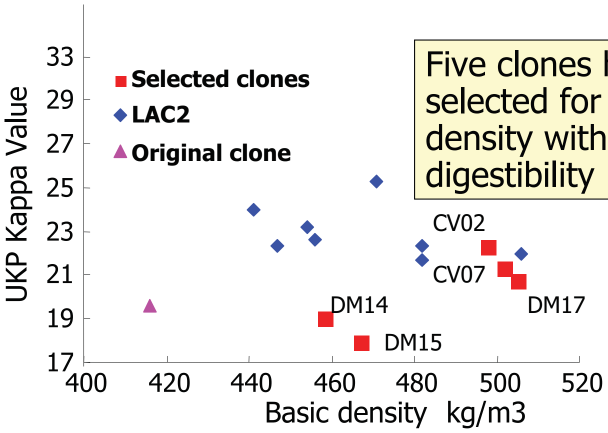




② Hybrid clones with heavier basic density

Improvement of basic density is one of our targets for getting pulp from a unit area as much as possible

- Selection of clones: Growth and wood quality
- Identification of clones by DNA markers



Five clones have been selected for heavier basic density with better digestibility

Basic density and cocking ability of Acacia hybrids and LAC2 chips
(Active alkali 20%)

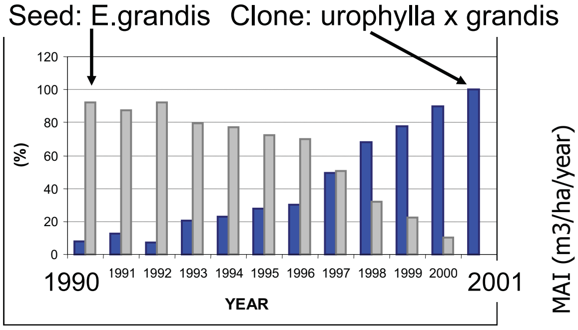
4. Issues & efforts on advancing hardwood plantation

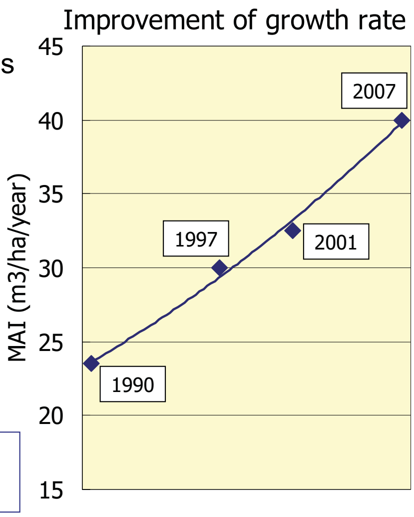
1. Improvement on productivity of plantation

⇒ Promotion of clonal forest

1)-① Effect of promoting clonal plantation in Brazil

Cenibra has long history of clonal plantation. Clonal plantation has been started in 1990. Rotation cycle is seven years.





Growth rate has been increased by almost 70% to 40m^3/ha/year in 2007.

② Outline of clonal plantation

Acquisition of clones

①Short term：acquisition from other organizations
②Long term：selection of plus trees at plantations
→hybridization between plus trees

propagation

propagation of mother trees for mass production

confirmation

①Growth performance of the clone should be confirmed at target lands
②About half of rotation cycle will be required for confirmation

commercial

It will take three to five years to start commercial planting with a newly acquired clone.

4. Issues & efforts on advancing hardwood plantation

1. Improvement on productivity of plantation

⇨ Promotion of clonal forest

2. Risk hedge against pests & diseases

⇨ Development of new clones

(Present status)
1) Eucalyptus: No clones available except K7
2) Acacia: Imported hybrid clones perform better so far

1)-① Acquisition of new clones in Eucalyptus

Year / Source	Clone No.	Species	Planted area	Remarks
2006 / China	DH3213	urophylla x grandis	2006: 60ha 2007: 23ha	CPFL (commercial)
	DH3226	〃		〃
	DH3327	〃		〃
2008 / China	GLGU9	〃	Trial in a small scale	
	GLWC3	camaldulensis x urophylla		
2008 / Thailand	H1	camaldulensis		
	H3	〃		
	H4	camaldulensis x urophylla		High pulp yield
2009 / Thailand	K51	camaldulensis	Trial scheduled	
	K58	unknown		
	K62	〃		
2009 / Vietnam	U6	urophylla		
		pellita (natural hybrids)		**40 clones**

② Susceptibility of the clones to disease

Acquired clones should be carefully evaluated for adaptability to the sites especially in higher rainfall region.

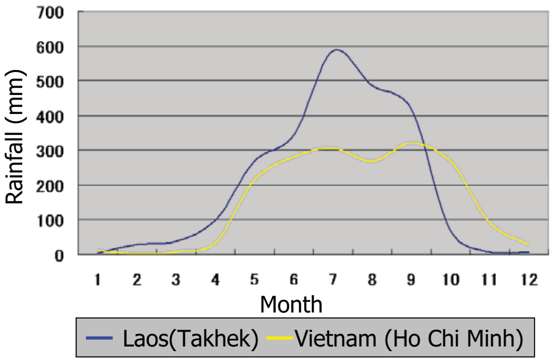

DH3213 from China (one year old)


Left: DH3213、Right: K7

③ Natural hybrid clones in Vietnam

Research center for Forest Tree Improvement (Vietnam)

1. There are many clones of hybrid between E.pellita and E.brassiana (Natural hybrids)
2. Selection has been conducted for growth.
3. Trials of selected trees is in progress. Performance is good so far.
4. Climate condition seems to be very similar in Laos.



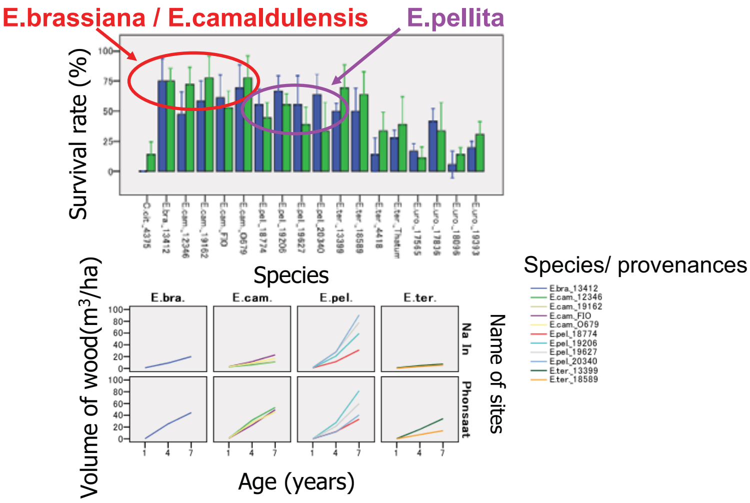
Trial site (Vietnam, 6.5years old))

2)-① Development of new clones: Species trial

①Survival rate : E.brassiana/E.camaldulensis>E.pellita

②Growth : E.pellita>>E.brassiana/E.camaldulensis

Hybrids between E.pellita and E.brassiana or E.camaldulensis should be good in Laos



② Selection & pollination

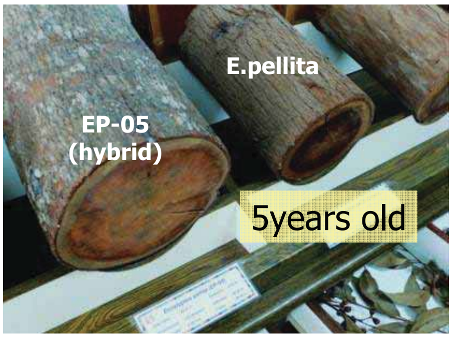
Creation of hybrids with high survival rate and good growth performance by hybridization between E.camaldulensis and E.pellita

・Selection in E.camaldulensis

Selected tree
(Age：seven years old)
H: 23.4m, DBH: 19.6cm

Process for creating superior clones

Grafting & promoting to flower → Hybridization → Selection

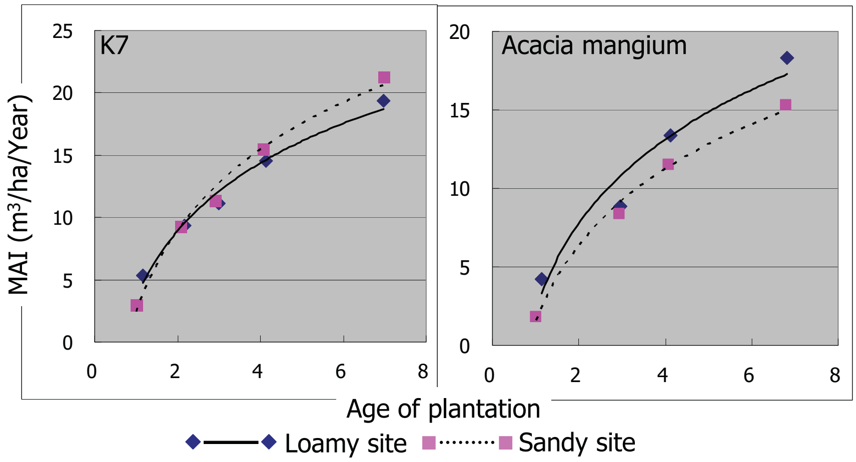


4) Acquisition of new clones in Acacia

Year / Source	Clone No.	Species	Planted area	Remarks
2005 / QPFL	QPFL No.1	hybrid (mangium x auriculiformis)	2006： 12ha 2007: 92ha 2008: 1,025ha	Higher pulpwood productivity
	〃 No.2	〃		
	〃 No.21	〃		
	〃 No.32	〃		
	〃 No.40	〃		Higher pulpwood productivity
2008 / FSIV & QPFL	〃 No.27	〃	Trial in a small scale	
	〃 No.28	〃		
	〃 No.49	〃		Higher pulpwood productivity
	TB11	〃		
	AH1	〃		
	AH7	〃		Straight
	AA7	auriculiformis		〃
	AA9	〃		〃

5) Policy for enlargement of plantation area

Matching of clones and sites is a very important factor to maximize pulp wood productivity per unit area



4. Issues & efforts on advancing hardwood plantation

1. Improvement on productivity of plantation
   - Promotion of clonal forest
2. Risk hedge against pests & diseases
   - Development of new clones
3. Management of soil nutrition
   - Fertilization of microelements

(Present status)
1) Less nutrients in our target sites
2) Symptoms of nutrient disorder, especially in Boron

1) Leaf analysis for nutrient level of soil

Soils in our plantation sites seems to contain less nutrients especially in macro elements

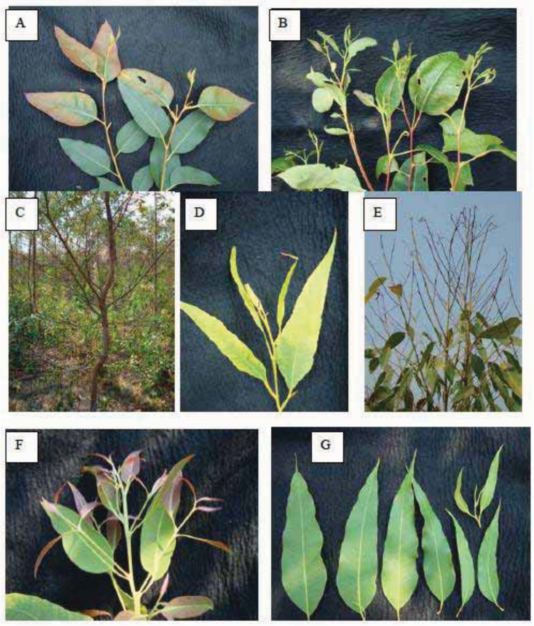
Summary of leaf nutrient level in LPFL plantations (macro elements)

			g/kg dry weight					
No. sample	Species		N	P	K	S	Ca	Mg
24	K7	Mean	13.8	0.9	9.9	1.1	4.0	1.6
8	G X U	Mean	15.1	0.8	7.3	1.2	4.0	1.8
	Adequate	Min.	18	1.2	9	1.2	2.1	1.1
		Max.	29	1.6	15	2.9	7.5	3.6

Summary of leaf nutrient level in LPFL plantations (micro elements)

			mg/kg dry weight				
No. sample	Species		Fe	Zn	Mn	Cu	B
24	K7	Mean	66.0	12.6	374.1	5.9	7.1
8	G X U	Mean	83.5	11.9	795.3	6.5	14.1
	Adequate	Min.	40	13	130	3.5	13
		Max.	100	29	2300	13.4	30

2)-① Boron deficiency in Eucalyptus



E.grandis x E.urophylla (china)

A: The emerging severe B deficiency in new leaves of GxU in dry season

B: Early phase of B deficiency – leaf cupping

C: Severe prolonged B deficiency – stem twist and forking

K7

D: The emerging severe B deficiency in new leaves of K7

E: Severe prolonged B deficiency – stem forking

F: the early onset of B deficiency – purple color of young leaves

G: normal leaves in a age gradient

② Boron deficiency in Acacia

Acacia hybrid

The same symptoms as in Eucalyptus

1. Leaf: yellowing can extend from the margin over the whole blade, developing leaves may be malformed with missing sectors
2. Stem: shoot tip death, multiple shooting from axillary buds

↓

Several trials have been established to elucidate adequate levels of macro and micro elements

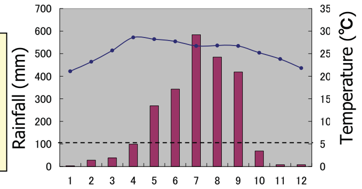
4. Issues & efforts on advancing hardwood plantation

1. Improvement on productivity of plantation
   ⇨ Promotion of clonal forest
2. Risk hedge against pests & diseases
   ⇨ Development of new clones
3. Management of soil nutrition
   ⇨ Fertilization of microelements
4. Challenge to environmental issues
   ⇨ Selection of species/clones for waterlogged sites

1) Plantation in waterlogged area

There is a significant level of waterlogged area mainly along major roads in Laos.

Main rainy season: May ～ September
Risk period for waterlogged: July ～ September



Climate in Laos (Thakhek)

As waterlogged area is basically very flat, it is very easy to operate plantation activities. But, high risk of disturbing growth will be expected.

Plantation area at waterlogged sites in 2008

Water depth (m)	Period for waterlogged（ha）				
	～1 weak	～2 weaks	～1 month	～2 months	2 months ～
1.5～			722	79	846
～1.5					
～1.0			33		
～0.5		712	109		
0	4,091				

Total	6,592
(Waterlogge d area)	(1,680)

2) Soil survey in the waterlogged area

There are some layers with iron rich or clay rich which may cause trouble to drain water

Measures below should be required

1. Tolerant species or clones to shortage of oxygen
2. Improvement of drainage

Red spots means shortage of oxygen in the soil periodically.

Iron rich layer

3) Adaptable clones and species

Higher survival rate: K7 and Acacia peregrinalis

	6 months after planting	11 months after planting	18 months after planting
A.pere grinalis			
		left:A.crassicarpa right: A.peregrinalis	left:A.crassicarpa right: A.peregrinalis
K7			
			left: A.crassicarpa right:K7

Growth performance should be carefully monitored for next two to three years

It is very risky but challengeable!