SOME EXPERIENCES WITH REAFFORESTATION OF ALANG-ALANG (*IMPERATA CYLINDRICA* L.) GRASSLAND IN INDONESIA

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ABSTRACT

In Indonesia the alang-alang grassland covers about 16-20 million hectares. It is considered unproductive land, therefore reafforestation of this grassland is very necessary. Some efforts including the policy of the Forestry Department, on national level and even in the field have been done.

Some techniques to suppress the alang-alang growth have been tried out including techniques of soil preparation, species selection and maintenance of plantations.

The reafforestation programme of alang-alang grassland has promising results for the increase of the forest area and will ultimately provide wood production, as well as an income for the rural people and soil protection benefits. The production of log and soft wood as raw material will increase.

The knowledge of silvicultural techniques for reafforestation activities in alang-alang grassland is enough to start an action programme, but nevertheless further research has to be done to find out still more appropriate techniques and to achieve better results.

The reafforestation method on the alang-alang grassland will mainly depend on the site situation and the objectives, especially the kind of wood that must be produced. Reafforestation directly with fast growing species will be carried out when soft wood will be produced. When more valuable wood should be produced, the system will be :

1. Planting fast growing species.
2. After the alang-alang is suppressed the slow growing and more demanding species is planted, while gradually the fast growing species is harvested.

A choice between exotic or indigenous species for forest plantation must be done, considering very carefully the advantages and disadvantages of these species. When the value, volume and production time of an exotic and an indigenous species are comparable, the indigenous one is the preferred choice. Use of exotic species is in principle only justified when a sustainable forestry is assured.

The reafforestation of alang-alang grassland will create positive socio-economic impacts as well as environmental impacts.

Key words: Reafforestation, Alang-alang grassland, Industrial Forest Plantation.

1. INTRODUCTION

The alang-alang (*Imperata cylindrica*) grassland is considered one of the degraded lands occurring in all tropic and subtropics areas. In Southeast Asia these degraded lands occur in very big areas.

Indonesia has millions of hectares of this kind of unproductive grassland (Soerjani, 1970; Ministry of Forestry, 1989), which formerly was tropical forest. These grasslands are present in almost all the Indonesian islands, especially in the outer islands.

There are several opinions about the causes of the establishment of this unproductive grassland. Most of them state that forest logging, forest fire, and shifting cultivation are the main causes (USDA, 1980; Dove, 1986). Like elsewhere in Southeast Asia these grasslands are certainly not natural or climatic climax grasslands, but rather anthropogenic or fire climax grasslands (Dove, 1986). They threaten not only the source of raw materials for forest products but also the ecological values. An intensive plantation programme could obviously solve the problem.

Considering that these areas are very large, the Department of Forestry has a policy to reafforestate those areas. However, according to several experiences, the reafforestation of this grassland is quite difficult because of a very low soil fertility, weed competition, and lack of suitable species (Selander, 1990). As a result of frequent fires and leaching, the soil pH is very low (3-3.5), and so the organic matter and nutrients are low. Usually the soils are hard clay soils (Soil Survey Riam Kiwa, 1988 in Vuokko, 1991). Such conditions are only suitable for specific species. Nevertheless these grasslands must be rehabilitated to serve as a greenbelt, to conserve the rainforests or to make them economically productive, for instance by developing the Industrial Forest Plantation.

Reafforestation of alang-alang grassland has both direct as well as indirect benefits (Sumitro, 1991). Direct benefits concern the economic value, while indirect benefits refer more to social and ecological benefits.

The economic value of reafforestation in alang-alang grassland can be shown by the conversion of these unproductive areas into productive forests, producing the raw material for several industrial uses, what will support the national economics.

The social benefits include employment in rural areas, especially in rural areas where there is serious unemployment and poverty. The plantations will make available the basic needs for the rural populations and will also encourage wood-based industries.

Sumitro (1991) points out that the ecological benefits are more related to environmental problems. In general ecological benefits embrace :

1. Preserving the soil stability and nutrient content of the soil while protecting against downstream siltation and floods.

2. Rejuvenating the soil by increasing the nutrient availability of the surface soil through nutrient cycles of the biomass.

3. Improving micro-climates for microflora and fauna as well as macro-climates and the habitats of wildlife.

4. Improving the water balance by reducing peaks of water discharge.

With regard to the background above, this paper will mainly deal with the characteristics of *Imperata cylindrica*, and the evaluation of the reafforestation programme in those areas.

2. CHARACTERISTICS OF *IMPERATA CYLINDRICA*

2.1. Botanical characteristics

Imperata cylindrica, of which the most common names are alang-alang, lalang or cogon, is a species of the family *Poaceae* (*Gramineae*), the subfamily : *Panicoideae*.

There are five varieties of *Imperata cylindrica* : var. *major*, var. *africana*, var. *europaea*, var. *condensata* and var. *latifolia* (Eussen, 1980).

Var. *major* occurs in Asia, Australia, East Tropical Africa and India; var. *africana* in Africa and Madagascar, var. *europaea* in the Mediterranean area, Central Asia and Central Sahara, var. *condensata* in Central region of Chile and var. *latifolia* in India.

This species is a perennial grass, 20 - 230 cm high. The shoots grow from rhizomes, which are white or yellow-white colored, sometimes pink to purple, and 2 - 4.5 mm in diameter. They consist of internodes, about 1.5 - 3 cm in length, becoming shorter to 0.5 cm at the apical ends or where the rhizome reaches the soil surface and forms a shoot, which occurs every 25 - 50 cm. At the buds one or more roots break through. The roots reach in heavy impervious soils to a depth of 15 cm, but in light soils to more than 85 cm. The leaves are upright, with a length of 150 - 250 cm, and up to 2.2 cm wide, narrow at the end with a sharp point. The leaves are green colored (Soerjani, 1970) and hairy at the base (Coster, 1938). The inflorescense is a spike-like panicle, 2.5-28 cm long and 0.6-2.5 cm wide (Hubbard, 1944). Each inflorescense contains about 700 seeds (Eussen, 1980).

The reproductive capacity of this species can be sexually or asexually. The sexual reproduction happens by way of seeds and the asexual by way of rhizomes. The seeds are easily dispersed by the wind (Sajise, 1972). The rhizome production is very high. Every node section can give risk to new plants. The degree of viability decreases as the number of nodes per fragment decreases (Ivens, 1975). This indicates that intensive cultivation can reduce *Imperata cylindrica* infestation.

2.2. Habitat

Imperata cylindrica var. *major* is represented in tropical and subtropical Asia by a series of habitat forms. It develops best in areas where there is continual cutting, grazing or treading. It grows in a wide range of habitats, from sand dunes to swamps and river margins, at elevations from sea level to 2,000 meter in the Himalaya (Hubbard, 1944) or up to 2,700 meter above sea level close to the equator (Soerjani, 1970). It is found in a wide range of soils varying from very poor to very rich soils (Soepardi, 1980).

Meys (1938) argues that the main cause of the establishment of alang-alang is the burning of vegetation. This species is very fire resistant because of its rhizomes. It is a fire climax community (William *et al.*, 1969), aggressive and able to colonize suitable areas at the first time.

Several fires can be caused by men, e.g. during the establishment of shifting cultivation fields, in order to establish grazing grounds for cattle, or by clearing strips along roads and railways by poachers and farmers. Nevertheless also natural fires can occur and these conditions are very susceptible for alang-alang. Such conditions can be found in areas left after logging or shifting cultivation activities.

In the shifting cultivation practice trees are felled down, the area is dried out and finally is burnt. In the beginning of the rainy season, after land preparation, rice, corn and legumes are sowed. The following dry season the infesting weeds, shrubs and alang-alang, as well as any resprouted tree stumps, are slashed and burnt again before a new round of crops is planted. After the third year the farmers usually abandon the field in order to clean out weeds and to restore surface organic matter and soil fertility (Driessen *et al.*, 1976). This is called the fallow period. When the fallow period is not sufficient enough and repeated burning takes place, shrubs and pioneers trees cannot grow and alang-alang will become the dominant vegetation (Williams *et al.*, 1969).

Another reason for the development of alang-alang grassland is the repeated logging activity. By this, trees are removed and gaps created. Herbs and climbers become increasingly prevalent, and low valued waste grasslands are formed without internal structure. When this kind of area is subjected to fire, alang-alang will soon dominate (Tanimoto, 1981). Therefore it is important to minimize the development of these grassland, i.e. by enrichment planting as soon as possible after logging activities.

3. EXPERIENCES WITH REAFFORESTATION PROGRAMMES OF ALANG-ALANG GRASSLAND IN INDONESIA

In Indonesia the development of forests in alang-alang grassland can be considered reafforestation, either afforestation or reforestation. Indeed according to the FAO definitions, afforestation means the establishment of forest in areas which were devoid from forests for more than 50 years, while reforestation refers to the reestablishment of forests in areas which were devoid from forests in less than 50 years. In Indonesia, alang-alang grassland occurs in both conditions, as is shown by an example in Riam Kiwa (South Kalimantan) (table 1).

Table 1 : Land cover of Riam Kiwa watershed, South Kalimantan.

Main land use type	Area (ha) 1926*	Area (ha) 1972*	Area differences (ha)	Remark
Primary forest	30, 000	26, 000	- 4, 000	decrease
Secondary forest	29, 800	9, 000	-20, 200	decrease
Alang-alang grassland	4, 200	28, 400	+24, 200	increase

* Potter (1987), in Sumitro (1991).

It appears from table 1, that in Riam Kiwa (South Kalimantan) in 1926 only a small part of alang-alang grassland was found. The evolution of land cover over a period of 46 years (from 1926 up to 1972) shows that increase of alang-alang grassland area goes with a decrease of either primary or secondary forests. It means that most of the alang-alang grassland is developed from forest in less than 50 years. Besides that, alang-alang grassland already existed in the early times. According to the interpretation above it can be stated that planting activities on the alang-alang grassland in Indonesia generally can be considered mainly as reafforestation activities.

Alang-alang is a very dangerous weed and must be eliminated by several management systems. Tjitrosemito and Soerjani (1991) state that there are three concepts of management of alang-alang grassland. It involves :

1. The improvement of management practices of existing man-made productive sub-systems to keep them sustainable productive. By this activity the new areas dominated by alang-alang would be reduced and eliminated.

2. The conversion of areas currently under alang-alang domination into productive subsystems. By this conversion, the wasteland would be more productive for either agriculture or forestry. By this activity also the ecological quality will be improved.

3. The prevention of fire which currently burns alang-alang and other associated vegetation annually. If fires are prevented, secondary succession can be expected to proceed naturally. The area will develop into secondary forests, provided that mother trees are still available to supply the necessary seeds.

In Indonesia alang-alang grassland occurs over all islands, and related to the development of Industrial Forest Plantation, priority should be given to alang-alang grassland and other unproductive land. Since alang-alang grassland is infertile, intensive silviculture needs to be implemented.

In order to have some information about reafforestation activities in alang-alang grassland, a discussion about the planning of reafforestation programmes, about the silvicultural activities (this includes soil preparations, choice of species, seedling transport and storage, planting, maintenance etc.), the possibility of pests and diseases, and the performance of reafforested alang-alang grassland arises.

3.1. Planning of reafforestation

The national forest policy reflects all programmes of forestry activity. In Indonesia national forest policy is stated in Five Year Development Plan (REPELITA). The latest national policy is REPELITA VI, which embraces all programmes within 1994/1995 - 1999/2000.

Related to the programmes of the Five Year Development Plan, the Department of Forestry will develop at least 6.2 million hectares of Industrial Forest Plantations until the end of REPELITA VI, including 1.8 million hectares of the existing forest plantations in Java. In addition to that 5.5 million hectares of critical land will be reforested (Anonymous, 1986; Government of Indonesia, 1993). The future plantations will be located in alang-alang grassland.

In order to have a relative success with the reafforestation in alang-alang grassland, the first step is a feasibility study which embraces growth rate of the main species, communication (roads and others transports), land ownership, available labor, etc. When the feasibility study has been carried out, the planning of reafforestation activities should be made.

This planning embraces plans for the whole project, including annual and long term work plans. Vuokko (1989) stresses that besides a long term financing plan the most important plan is the annual budget. Detailed planning of field operations requires good quality maps. When maps are already available, the annual and long term plans for reafforestation activities should be realized. The realization of reafforestation activities will be encouraged by the silvicultural knowledge.

3.2. Silvicultural techniques

As alang-alang grassland is a very harsh environment, the reafforestation of this grassland is quite difficult. Indeed its roots and rhizome systems compete with other species for moisture and nutrients. The soil nutrient content is very low, due to leaching and fires. Consequently the tree seedlings have difficulties to develop. Usually the soils exist of hard clay in which the development of tree roots is difficult (Vuokko, 1989). Because of these several difficulties, information about silvicultural techniques is very important. This includes soil preparations, species selection, seedling transport and storage, planting, maintenance (weeding, fertilization etc.).

Soil preparations in alang-alang grassland can be done either mechanically or by using herbicide treatment. Mechanical treatment is applied by using tractors or bulldozers, in areas with relatively flat topography. In order to facilitate the preparation, it is usually applied during the dry season, at a certain moisture condition. In Riam Kiwa (South Kalimantan) the area is plowed twice with a disc plow and cultivated once by a rotavator or a harrow (Hadi *et al.*, 1988). When the topography is relatively steep, systemic herbicide treatment is used as soil preparation.

In the systemic herbicide treatment, chemical solutions are commonly used. In alang-alang grassland Glyphosate is normally used (Pratiwi and Nazif, 1989 a; 1989 b; 1989 c; 1989 d), usually 6 l/ha (Hadi *et al.*, 1988; Hadi and Adjers, 1989) up to 7 l/ha (Nazif and Pratiwi, 1989; 1990 a; 1990 b). Because the herbicide will partly be washed out in the rainy season, thus increasing the costs, the spraying must be done in the dry season.

Another site preparation is the burning of grass prior to planting. Nevertheless Vuokko (1991) states that as alang-alang has a rapid growth after burning, this method can not be considered as sufficiently effective.

Both soil preparation techniques and herbicide treatment, although effective with regard to the reafforestation result, should be critically researched on their global ecological and environmental impacts. This topic requires special attention.

Species selection is considered as the essential stage, because appropriate species will influence the reafforestation success. As reafforestation in alang-alang grassland is very difficult, information about suitability of the species is needed.

Considering that alang-alang is a light demanding species and grows on poor soils, it can be suppressed by others species which should be (Soerjani, 1970; Sajise, 1980; Soerianegara, 1980):

1. light demanding,
2. fast growing tree species, meaning that in a relatively short period the tree canopy covers completely the ground,
3. reproduced easily by seeds or by vegetative means,
4. resistant to common pests and diseases and to fire,
5. tolerant to low soil pH,
6. tolerant to water stress,
7. tolerant to low soil nutrient level, especially N and P,
8. tolerant to the allelopatic influence of alang-alang,
9. tolerant to the mechanical effect of abundant alang-alang rhizomes.

Vuokko (1991) points out that, according to his experience in South Kalimantan, only a few indigenous species are suitable for reafforestation of alang-alang grassland. Indeed the natural forest vegetation in most parts of the country belongs to the tropical rain forest, meaning that the species require shade in their youth. Fast growing species with a dense crown seem to be very promising for the first stage of reafforestation in alang-alang grassland. These species will shade out and suppress the alang-alang grassland.

According to Hadi and Adjers (1989), *Gmelina arborea* has the widest crown and is the best species for shading out the grass in Riam Kiwa (South Kalimantan). They recommend that for the reafforestation of alang-alang grassland the species should have a high survival rate and a fast growth. However some slow growing species can also be recommended as far as they can survive in those areas. But the risk exists that these slow growing species need more weeding, so that the cost for maintenance is higher than with fast growing species.

Another important fact that should be taken into account is seedling handling. The seedlings must be delivered from the nursery to the planting site in a good condition. By this way the survival will be high and the seedlings will continue their growth after planting. However some species have very sensitive seedlings, e.g. *Paraserianthes falcataria, Eucalyptus* spp. and *Swietenia* sp. For these species, special attention must be paid to their quick transport, proper storage and watering in the field (Vuokko, 1991).

Planting should be done in the early rainy season, after land preparation and before alang-alang has covered the land. So the seedling can properly establish itself before the dry season begins.

Weeding is necessary to reduce the competition for light, nutrients and water between trees and weeds. It can be done either manually, mechanically or chemically. Manually by using hands or simple equipment, mechanically by using tractors or chemically by using herbicides.

Fertilization is necessary in the reafforestation of alang-alang grassland, as soil analyses have shown that the nutrient level in alang-alang grassland is very low (Vuokko, 1991). Fertilization on alang-alang grassland in South Kalimantan showed a clear effect on tree growth. The effect depends largely on the type of fertilizer. It seems that Nitrogen, Phosphate and Kalium (NPK) fertilizers give the best effect, even for nitrogen fixing species. However the direct effect of one application is short. Even with a relatively small application per tree, the fertilizer is adequate (50-100 gr). The cost of fertilizing is probably paid back by the reduced need of successive weeding operations.

Monoculture plantations lead to ecological unstability, causing an emergence of potential pests and diseases. These risks must be taken seriously, the more so as pests and diseases easily spread.

The failure of plantations in several countries, including Indonesia, is usually due to pest and disease problems. For instance, the planting programmes of the multipurpose tree *Leucaena leucocephala* in many regions in Southeast Asia, including Indonesia, have recently failed, mainly due to the leaf-sucking insect pest, *Heteropsylla cubana*. In Java, a wood-boring long-horn beetle, *Xystrocera festiva*, is threatening the success of fast-growing *Paraserianthes falcataria* plantation. But tree species introduced in Central Africa, especially *Eucalyptus* spp. and pines, are healthier and more free from diseases than in their original conditions (Selander, 1990).

3.3. Performances of reafforested alang-alang grassland

Some evaluation of reafforestation on alang-alang grassland in Indonesia has been carried out since the 1930's especially in Sumatra and since the 1980's in Kalimantan. Therefore the performance of the reafforestation in alang-alang grassland can be reviewed for the further development of these programmes.

All the reafforestation programmes aim to develop forest, with direct and indirect benefits. Therefore several stages must be followed. In this respect Valli (1989) mentions species and provenance trial, seedling production, plantation establishment and plantation maintenance.

3.3.1. Riam Kiwa, South Kalimantan

There are about 1 million hectares of alang-alang grassland in South Kalimantan (Hadi *et al.*, 1988; Vuokko, 1989). This area can be used as land for reafforestation activities. In Riam Kiwa several reafforestation activities have been done in order to rehabilitate the degraded land.

3.3.1.1. Species trial

The species trial aims to make a correct choice of species in correspondence with the site. This should provide the basic information in order to make decisions and policy. The success of reafforestation will depend on the adequate trial.

The research of Hadi *et al.* (1988) showed that in Riam Kiwa the survival rates of some *Eucalyptus* spp. are very bad, so that they cannot be used for reafforestation in alang-alang grassland in this region. *E. pilularis, E. intermedia, E. grandis* and *E. phaeotrichia* were almost completely wiped out during the first year after planting. The best performance among the *Eucalyptus* spp. is showed by *E. camaldulensis* and secondly by *E. pellita.*

Contrary to that, several *Acacia* spp. have been found to the promising fast growing species, e.g. *A. mangium, A. leptocarpa, A. auriculiformis, A. crassicarpa,* and *A. cincinnata.* They have high survival rates and a fast closure of the canopy. Other species like *Gmelina arborea* have a fast closure of the canopy and suppress the alang-alang grassland. This species produces large branches in open conditions but it seems that it requires better soils.

Paraserianthes falcataria is another promising species with high survival rates and good growth. Among the native species, three of them have performed well : *Cassia siamea, Peronema canescens* and *Swietenia macrophylla.* The last two are slow growing species but produce a valuable wood.

Shade tolerant species have not performed well, like *Durio* sp., *Agathis* sp., and *Dipterocarpus* sp. One of the *Dipterocarpaceae* species that can survive in the open areas but with a slow growth rate is *Anisoptera* sp.

The research of Hadi *et al.* (1988) showed that the most promising species in Riam Kiwa are fast growing nitrogen fixing tree species, i.e. *Acacia crassicarpa, A. mangium, A. leptocarpa, A. cincinnata, A. auriculiformis* and *Paraserianthes falcataria.* Other fast growing species are *Eucalyptus camaldulensis, Cassia siamea* and *Gmelina arborea.* However *Eucalyptus camaldulensis* should be used with reservation as its thin and narrow crown is not able to shade out the grass. Slower growing promising species are *Peronema canescens* and *Dalbergia latifolia.*

3.3.1.2. Provenance trial

Species trial should be followed by provenance trial. By this way the best seed sources suitable for large-scale reafforestation can be identified.

In the provenance trial of *Acacia mangium,* the average survival rates varied between 92 and 100 per cent. The best growth was yielded by the provenances : Claudie River, Cardwell, Kuranda and Bloomfield all from Queensland, Australia. Seed collected in Subanjeriji, South Sumatra, yielded trees of good quality and fast growth. The worst growth was yielded by the Sanga-Sanga provenance from East Kalimantan. The provenance with good result can be recommended as a source for the new plantations, while the provenance with the worst results should not be used for plantations. Economically the worst provenance will not give the expected benefits: either they are slower growing or they have extremely poor stem quality.

3.3.1.3. Growth

With regard to cultivating and spraying with herbicide, differences in growth have been demonstrated.

From four species (*Acacia mangium, Paraserianthes falcataria, Gmelina arborea* and *Swietenia macrophylla*) it looks that *A. mangium* and *P. falcataria* respond much better to the Triple Super Phosphate (TSP) treatment when the soil is mechanically cultivated in comparison with a herbicide treatment.

3.3.2. Riam Kanan, South Kalimantan

The provincial government has made yearly efforts to reforest 35, 000 hectares of alang-alang grassland in Riam Kanan Valley since 1973 (Dove, 1986). The efforts consisted of tilling strips of grassland with a tractor, followed by planting of *Pinus merkusii* seedlings. The objective is double, i.e to reduce the grassland areas and to increase the forested area in the valley. The first purpose aims to get the grassland more valuable, either economically or ecologically. The second objective wants (Dove, 1986) :

1. to guarantee a stable year-long supply of water to the reservoir,
2. to reduce the rate of siltation in the reservoir,
3. to increase the nutrient level of the water flowing into the reservoir,
4. to increase the nutrient level of the water flowing out of the reservoir,
5. to protect and restore populations of endangered species,
6. to provide timber for a paper mill downstream.

Nevertheless this reafforestation effort has been unsuccessful. In 1982, it was calculated that 9 years after the reafforestation almost 93.5 per cent of the reafforested area had returned to the original grassland (Musa *et al.* in Dove, 1986).

The people in Riam Kanan preferred to plant rubber trees (*Hevea braziliensis*) instead of pines (Dove, 1986). By planting rubber trees people can work as labor by tapping the rubber sap, instead of applying agroforestry systems. Nevertheless, the most important factor for reafforestation success in those areas seems to be the tree species choice. It should be a fast growing species and a more valuable one for the local people so that the plantation has also a direct benefit. The valuable and marketable species can only be planted in a second phase, prepared by the pioneer tree species. However, these are more slow growing species. In this stage the rural people can be involved either as labor for this programme or in an agroforestry system.

3.3.3. Aek Na Uli, East Sumatra

In the 1930's Fluyts did some experiments of reafforestation of alang-alang grassland in an area below 1000 meters elevation, by using *Pinus merkusii* (Govers, 1953). This species was chosen because it is easy to establish in lowland areas, even on poor soil. The main purpose of *Pinus merkusii* reafforestation is wood production for the paper industry.

The study showed that in the first year fire is one of the hazards of young plantation, but after several years they are fire resistant. Reafforestation in alang-alang grassland by using *P. merkusii* from Tapanuli origin is sensitive to *Millionia basalis* attacks. It means that pine seed from Tapanuli should not be used in reafforestation extension in Aek Na Uli.

3.3.4. South Sumatra

Masano (1984) points out that *Pinus merkusii, Eucalyptus deglupta* and *E. alba* are suitable to grow on acid, infertile soils and can compete with alang-alang. These species can be recommended as reafforestation species in alang-alang grassland.

3.3.5. Kediri Forest District, East Java

In the 1970's on Kediri Forest District, a reafforestation was carried out by Perhutani (Indonesia's Forest Enterprise) in an area above 1000 meters elevation.

The species was *Pinus merkusii*. The result has been successful, but as this species originally does not grow in the lowland area, adapted habitat forms are necessary (Purwanto, 1980).

3.3.6. Pests and diseases

In order to have more detailed information about pests and diseases, the future possibility of the risk for related tree species is discussed underneath (table 2). It appears from table 2 that the exotic species *Acacia mangium* has the most pests and diseases as compared with other species. Other exotic species like *Acacia auriculiformis* and *Paraserianthes falcataria* have also relatively many pests and diseases. On the other side, as compared with exotic species, the indigenous species are relatively resistant against pests and diseases. Examples are *Swietenia macrophylla*, *Peronema canescens* and *Dipterocarpaceae* species which have only relatively slight signs of pests and diseases. *Pinus merkusii* has the most pests and diseases, as compared with other indigenous species.

4 . DISCUSSION

In Indonesia the alang-alang grassland covers about 16 - 20 million hectares. This grassland is considered unproductive land as nothing can be harvested when using such land. The increasing demand of land for forest areas and wood production implies efforts for conversion of the alang-alang grassland into forests. Some efforts, including the policy of the Forestry Department, on national level and even in the field have been done.

Based upon the results of earlier studies in alang-alang grassland, the Forestry Department concluded that 6.2 million hectares of Industrial Forest Plantation must be developed before the year 2000, including 1.8 million hectares of the existing plantations in Java (Government of Indonesia, 1993). This Industrial Forest Plantation is mostly located on the alang-alang grassland. Conversion of alang-alang grassland into Industrial Forest Plantation means that reafforestation activities will be carried out in order to increase the forest area and ultimately to produce wood.

The change of land from alang-alang grassland into forest will influence the social-economical conditions of the local people since the productivity of the land will increase. No products can be harvested from this grassland, while the forest can provide the rural people not only with wood but also with some other forest products such as honey, firewood etc.

Alang-alang is a very obstinate species which can grow easily on very poor soils. Its soil characteristics are mostly low fertility, low pH (pH 3-3.5), high Al-content and poor soil structure. The species has a very high productive capacity both by seeds and rhizomes. The rhizome production is very high. Every node section can produce a new plant. Both low soil fertility and high reproductive capacity of the species are very substantial obsticals for the reafforestation of the alang-alang grassland. Therefore specific silvicultural techniques are needed.

Table 2 : Some pests and diseases on reafforested areas in, Indonesia*

No.	Tree species	Pests	Diseases	Symptoms
1.	Acacia mangium	pine-holes beetles	-	pine-holes on some felled trees
		wood-boring larvae of cerambycid beetles	-	boring-wood on some felled trees
		subterranean termites	-	feeding on the wood which was in contact with the ground
		the bagworms, the tussock moths and Hypmeces squamosus	-	defoliation
		Aegus acuminatus	-	stem-holes
		Megapis dorsata	-	young-leaf sucking
		Pteroma plangiophleps, Apogonia sp., Leptoderatus compresus, Exopolis ipoleuca	-	leaf-feeding
		-	Agaricales sp.	grew aggressively directly from the bark wounds or the pine holes on some felled trees
		-	Meliola sp.	blackish superficial spots on the newly planted seedlings
		-	Corticum salmonicolor	bark-destroy
		-	Phytium sp. and Fusarium sp.	root-rot
		-	Formes sp.	stem-rot

Table 2 (Continued).

No.	Tree species	Pests	Diseases	Symptoms
2.	Acacia auriculi-formis	-	Agrobacterium tumefaciens	gale-like, girdling and convoluted tumors on the thinner stems and branches
		-	Uromyces digitatus	gall-like brownish pustules on the leaf
		-	Ganoderma lucidum	heart-rot
		-	Formes sp.	stem-rot
		-	Phytium sp.	root-rot
		Xylosandaus compactus	-	damage on branch and stem seedling in the nursery
3.	Anthocephalus ca-damba	Macrotermes malaccensis	-	bark-damage
4.	Dipterocarpaceae	Nanophytes shoreae	-	seed attack on Shorea ovalis, S. laevis, S. smithiana, S. pauciflora and Hopea odorata
		Alcidodes dipterocarpi	-	fruit attack on Dipterocarpus cornutus and S. smithiana.
		-	Fusarium sp., Diplodia sp., and Ganoderma sp.	stem-rot
5.	Duabanga sp.	leaf-rolling and leaf-sucking aphids	-	defoliation
6.	Eucalyptus spp.	Macrotermes gilvus, M. malaccensis, Microtermes sp., Schedorhinotermes malaccensis, and Coptotermes sp.	-	bark damage in roots, root collar and stem
		Helopeltis theivora and Aphis gossypii	-	sucking some leaf-cells solution
		Zenzera coffeae	-	bark-destroy
		-	Pestolozia sp. and Convularia sp.	leaf-spot
		-	Nectria sp.	stem-cancer
		-	Pythium sp.	root rot

Table 2 (Continued).

No.	Tree species	Pests	Diseases	Symptoms
7.	Eucalyptus alba	Zeuzera coffeae	-	pine-holes
8.	Eucalyptus deglupta	Zeuzera coffeae	-	pine-holes
9.	Eucalyptus urophylla	Macrotermes malaccensis and Schedorhinotermes malaccensis	-	attack on stem and root
		-	Fusarium sp. and Phytium sp.	root-rot
10.	Enterolobium macrocarpum	larvae of Glyphodes sp. and Eu-rema sp.	-	defoliation
11.	Gmelina arborea	Prionoxystus sp.	-	pine-holes
12.	Swietenia macrophylla	Hypsipula robusta	-	destruction of terminal buds, forking and crooked stem
		-	Corticium salmonicolor	stem-rot
13.	Leucaena leucocephala	-	Heteropsylla cubana	dumping plant louse
14.	Peronema canescens	Meliola sp.	-	defoliation
15.	Anthocephalus chinensis	Meliola sp.	-	defoliation
16.	Paraserianthes falcataria	Eurema sp.	-	seasonal defoliation of large trees
		Xystracera festiva	-	boring cerambycid
		-	Diplodia sp. and Ganoderma pseu-doferrum	red root-rot
		-	Ustulina deusta	ustulina-rot
		-	Macrophomia phaseolina	black root-rot
		-	Roselina bunodes	roselina-rot

Table 2 (continued).

No.	Tree species	Pests	Diseases	Symptoms
17.	Pinus merkusii	Cryptothelea variegata, C. pseudo and Nesodiprion biremis	-	feeding of flower and leaf
		-	Rhizoctonis sp., Fusarium sp., and Phytium sp.	seedling dumping-off
		-	?	fox tailing
19.	Agathis loranthifolia	-	Aecidium fragiforme	damage on leaf
		-	Corticium salmonicolor	stem-rot
20.	Tectona grandis	Lepidiota stigma	-	root damage
		Phases damar	-	stem damage
		Neotermes tectonae	-	stem damage
		Xyleborus destruens	-	stem damage
		Duomitus ceramicus	-	stem damage
		Pyrausta machaeralis	-	leaf-feeding
		Hyblaea puera	-	defoliation
		Valanga nigricornis	-	leaf-destruction
		-	Pseudomonas solanace-arum	withered on the young trees
21.	Schima sp.	leaf-rolling and leaf-sucking aphids	-	defoliation
22.	Trema sp.	-	-	minor types of damage, including leaf galls, slight defoliation and die back
23.	Vitex sp.	-	-	minor types of damage, including leaf galls, slight defoliation and die back
24.	Artocarpus sp.,Anisoptera sp.	defoliator	-	very slight sign

* Compilation of data from Intari and Santoso (1990); Hardi and Intari (1990) and Ngatiman (1990).

Silvicultural techniques that have been studied, deal with soil preparation, species selection, seedling storage and transport, planting and plant maintenance.
There are two possibilities of soil preparation, mechanically and chemically. Mechanical soil preparation includes deep plowing by tractor. The method is recommended for flat topographic and carried out in the dry season. Deep plowing brings the rhizomes of alang-alang on the soil surface and lets them dry. This way, the reproduction capacity is delimited. Chemical soil preparation is preferably done by using systemic herbicides. It is also carried out in the dry season. The systemic herbicide is preferably chosen because it works systematically through the cycles of the physiological solution. Therefore, the application of this herbicide kills the individual of the alang-alang as well as its rhizome. However, both techniques should be researched on their overall impact.

Selected species for reafforestation on alang-alang grassland should be capable to win the competition for light, water and nutrients against alang-alang. Some characteristics of preferred species are: light demanding, fast growing or tolerant. Seedling handling should be done carefully to provide good initial plants. The planting should be carried out at the beginning of the rainy season in order to have good reafforestation growing conditions.

In order to increase the success of the reafforestation in alang-alang grassland, specific cultivation systems should be created. Establishing specific systems will depend on the kind of wood to produce, either softwood or hardwood. Reafforestation directly with fast growing species could create relatively quickly softwood as a source of raw material for example pulpmills, firewood etc. In this system, besides species selection, the competition capability of species should be increased by fertilization, weeding and controlling pests and diseases of the main trees. By doing so the main trees will grow up until the canopies cover all over the land surface, through which the growth of alang-alang will be suppressed.

Hardwood is mostly produced by slow growing species, however direct planting of slow growing species on alang-alang grassland will meet several difficulties and ultimately will not succeed. The only possibility is to make a combination with fast growing species. The cultivation system will be :
1. Planting fast growing species.
2. The slow growing species is planted in between the fast growing species after the alang-alang is suppressed.

According to the growth of the slow growing species, the fast growing species can gradually be harvested. Finally the slow growing species plantation will establish itself to produce hardwood.

Establishing new forest by reafforestation of alang-alang grassland faces some difficulties in species selection because all species are introduced in relatively new environment. The first difficulty will be the choice between exotic or indigenous species because both of them have some advantages and disadvantages.

Indigenous species have some important biological advantages, e.g (Budowski, 1984; Evans, 1984 and Zobel *et al.*, 1987) :

1. Growth of natural stands, that provides some indication of possible performance in plantation.

2. The species are adapted to the environment, and already filling an ecological niche of several fauna and flora. It means that those species are less susceptible to serious damage from pests and diseases, as far as controlling agents (predators, viruses, climatic factors) are already present.

3. Even in monoculture, indigenous species are generally considered more ecological valuable than exotic ones for the conservation of native fauna and flora.

4. The timber is likely to be known to local wood-using industries.

For these reasons, if indigenous species grow well in plantations on reafforestation sites, there is no reason to choose an alternative. Indeed, for reason of conservation, if the growth and quality of two species, one indigenous and the other exotic are comparable, the indigenous species is to be preferred. But when there are no suitable indigenous species, some trial must be done and introduction of exotic species must be considered.

Disadvantages of indigenous species are (Evans, 1984; and Zobel *et al.*, 1987) :

1. Most of the indigenous species are slow growing species.

2. Especially in tropical forest, the seedlings of most indigenous species need shadow for their growth. It means that for reafforestations in open areas, like in alang-alang grassland, these seedlings need more shadow in the first stage of their development.

On the other hand the characteristics of exotic species are relatively different from those of indigenous species. Some introductions of exotic species show very successful results for the reafforestation in some tropical countries. There are several advantages of reafforestation by using exotic species, such as :

1. An increased chance to find a species well suited to the planting site.

2. An exotic species is far from its natural habitat and is therefore often free from pests and diseases.

3. Most of the exotic species are fast growing species and can easily grow in open

areas. They increase the desired wood production in a short time and result in a lowering of rotation ages, increasing by this economic returns.

4. Frequently the exotic species are biologically more suited to some marginal land like grassland or scrub forestland than the indigenous species are.

5. The high productivity of the cultivated exotic species in the tropics, which produce four to ten times more wood than the indigenous forests, enables a restricted area of grassland to produce a volume of wood on a much larger scale than poorly managed tropical forest.

6. The faster growth of exotic species can satisfy the increasing demand for wood and even contribute to reducing deforestation because plantations are more productive than natural forests by a two- to ten fold factor.

Nevertheless despite their advantages, exotic species have some problems, such as (Zobel *et al.*, 1987):

1. Pests of different types will appear and thus will continue to spread at very high rate.
2. Exotics are rarely best in areas containing good and diverse species.

Examples of promising indigenous and exotic species are given in table 3.
In tropical countries reafforestation by exotic species increases rapidly due to the need of wood either for local people or for export. The latter aims to profitability. Nevertheless some constraints must be considered especially concerning pests and diseases.

Exotic species far from their natural habitat are not always free from pests and diseases. *Acacia mangium*, which is considered a promising species in some areas in Indonesia, has in fact the most pests and diseases as compared with other exotic and indigenous species. The indigenous species are relatively resistant against pests and diseases.

Its appears that *Acacia mangium* can reach an increment of 44 m^3/ha/year for the production of energy wood, with a rotation of 10 years. This means that after 10 years it can produce 440 m^3/ha. On the other side, the indigenous *Dalbergia latifolia* which can also be used as energy wood has an increment of 19 m^3/ha/year, with 15 years rotation. This means that after 15 years it can produce 285 m^3/ha. The exotic species produces more wood in a shorter time than the indigenous one. Therefore it is considered more profitable than the indigenous one.

Table 3 : Promising tree species for reafforestation of alang-alang grassland in Riam Kiwa, South Kalimantan.

Species	Increment (m^3/ha)	Rotation (Year)	Use
Native species			
1. Peronema canescens	15	10-30	construction wood
2. Swietenia macrophylla	15	10-30	construction wood
3. Dalbergia latifolia	19	15	energy wood
4. Pinus merkusii	20	8-10	fibre and pulp wood
Exotic species			
1. Acacia mangium	49 14-44	10 4-10	pulp wood energy wood
2. Acacia auriculiformis	23-30	5-10	energy wood
3. Gmelina arborea	20	8-10	fibre and pulp wood
4. Paraserianthes falcataria	20-38 45 15	8-10 15 10-30	pulp wood energy wood construction wood

* Compilation from: Mangundikoro (1984); Alrasyid (1989).

Speaking about the value of wood, both indigenous and exotic species have important values. Most of the indigenous species are used as a source for construction wood, fibre wood, energy and pulp wood, while exotic species are more used as a source for pulp and energy. Hence it can be stated that indigenous species although they are slow growing are more valuable than exotic ones if construction wood will be produced.

With regard to the reafforestation programme of the alang-alang grassland in Indonesia both species, exotic or indigenous, can be considered for reafforestation, taking into account their advantages and disadvantages.

Considering that reafforestation in alang-alang grassland is very difficult, because of low fertility and the alang-alang grasses are light demanding, the first stage to suppress this species is by using light demanding species. The most light demanding species are exotic trees. In the second stage, when alang-alang is already suppressed, the indigenous species are planted while the exotic species are harvested. By doing so, ecological as well as economic profitability can be achieved.

Ecologically, the indigenous species can survive, while alang-alang can be suppressed. Economically, the exotic species can produce pulpwood or energy wood and in the long term the indigenous one will produce more valuable wood such as construction wood, fibre wood etc. When exotic species are planted without replacement by indigenous species, the disaster of biodiversity will appear. Indeed by doing so, the indigenous species will be shifted by the exotic species and this will result in a marginal kind of diversity. This situation will lead to the loss of biodiversity as a whole.

The conversion of the alang-alang grassland into forest land will create significant impacts upon the environment and also socio-economical impacts for the people at surrounding areas.

There is some environmental impact due to the conversion of alang-alang grassland into forest land. The most significant impact is the change of vegetation from grass into trees. The height of trees is normally higher than alang-alang grass. Trees will break the wind through that its speed will be decreased and that will ultimately give better conditions to the village or settlement nearby. Beside that micro-climate will change. The temperature and humidity under shadow of the tree plantation is better than in the alang-alang grassland. This condition will create new environmental conditions which can stimulate the growing of underground species, bryophyte, etc. Using various tree species on every parcel or block in every wood plantation and creating a new micro-climate as discussed above will increase the plant species diversity. Increasing the plant species diversity will encourage an increase of animal species diversity.

A negative impact will occur when the forest plantation is a monoculture. By pests and diseases spreading, the made forest will vanish.

Converting alang-alang grassland into forest land will extend the existing forests. This means increasing oxygen production and carbon sink.

Establishing forest on the alang-alang grassland and forest plantation maintenance will create jobs for people in the surrounding area. Beside that secondary forest products, such as honey, gaharu, etc; will increase the income of the people in surroundings.

5. CONCLUSIONS

1. The reafforestation programmes of alang-alang grassland has promising results for the increase of the forest area and will ultimately provide wood production and benefits for the rural population. The production of log and soft wood as raw material will increase.

2. The knowledge of silviculture techniques for reafforestation activities in alang-alang grassland is enough to start an action programme, but nevertheless further research has to be done to find out still more appropriate techniques and to achieve better results.

3. The reafforestation method on the alang-alang grassland will mainly depend on the site situation and the objectives, especially the kind of wood that must be produced. Reafforestation directly with fast growing species will be carried out when the soft wood will be produced. When more valuable wood should be produced, the system will be :

   1. Planting fast growing species.

   2. After the alang-alang is suppressed the slow growing and more demanding species is planted, while gradually the fast growing species is harvested.

4. A choice between exotic or indigenous species for forest plantation must be done, considering very carefully the advantages and disadvantages of these species. When the value, volume and production time of an exotic and an indigenous species are comparable, the indigenous one is the preferred choice. Anyway each silvicultural technique should assure a sustainable forestry.

5. The reafforestation of alang-alang grassland will create positive socio-economic impacts as well as environmental impacts.

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