AGROFORESTRY SEBAGAI USAHA REKLAMASI LAHAN ALANG-ALANG (*Imperata cylindrica*) PADA USAHATANI SKALA KECIL

AGROFORESTRY AS RECLAMATION PATHWAY FOR *IMPERATA* GRASSLAND USE BY SMALLHOLDERS

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ABSTRAK

Sistem agroforestry sangat memungkinkan digunakan untuk merehabilitasi lahan alang-alang dalam rangka mengatasi kemiskinan seperti halnya memelihara hutan yang sudah ada dengan diversitasnya. Dalam hal ini program penelitian sehubungan pendekatan agro-ekosistem sudah dimulai.

Analisa sistem dari lahan alang-alang, beberapa hipotesa untuk penelitian lebih jauh serta beberapa pengalaman "alley croping" yang dapat digunakan, dibahas dalam tulisan ini.

Sudah disadari bahwa reklamasi lahan alang-alang sangat kompleks. Alang-alang sangat erat hubungannya dengan faktor abiotik, tanah dan iklim. Begitu pula erat hubungannya dengan interaksi komunitas tanaman, pola tanam dan sistem usahatani, kebijakan pemerintah dan pengaruh lingkungan sosial. Semua faktor tersebut perlu diperhatikan dalam pengolahan lahan alang-alang.

Alley croping yang mendekati atau serupa dengan sistem bera dengan dibiarkannya semak tumbuh, dinilai dapat memberikan andil dalam merehabilitasi lahan alang-alang. Dalam hal ini pengalaman penelitian di Lampung menunjukkan bahwa Gliricidia sepium *dan* Peltophorum dasyrachis *memberikan hasil yang menggembirakan. Tanaman ini juga dapat diperlakukan dengan pemangkasan dalam rangka menghasilkan ruang tanam dalam sela barisannya dan naungan yang kompak bila dibiarkan tumbuh.*

ABSTRACT

Agroforestry may contribute to the process of using imperata grassland to help alleviate poverty as well as allow protecting remaining forest and their biodiversity. A program of research an inventory of the agro-ecosystems was made in which Imperata plays a major role.

Systems analysis of imperata grasslands, some hypotheses for further research and some experiences with rational alley cropping as shade-based Imperata control strategy are discussed in this paper.

It has been aware that reclaiming Imperata grassland is very complex. Imperata has relations with abiotic factor, soil and climate. It also deals with plant community, cropping and farming system, the notion of 'government', and neighboring. All factors should be considered in order to reclaim Imperata grassland.

Alley cropping which is a bit closer to the bush fallow system may give a great contribution to Imperata grassland rehabilitation. Candidate tress such as *Gliricidia sepium* and *Peltophorum dasyrachis* gave consistent yield also survive the set back pruning and develop a proper tree canopy when left to grow.

INTRODUCTION

Although the specific estimates of the area covered by Imperata grasslands in Indonesia differ, there clearly is a large area involved which is not intensively used at present. Intensification of the use of these lands may be one of the factors which could reduce the need for further forest conversion. Potentially, intensifying the use of these lands may help alleviate poverty as well as allow protecting the remaining forests and their biodiversity, and should thus be high on the development agenda. Agroforestry may contribute to this process and the Imperata grasslands, were chosen as priority area for research for ICRAF's regional research programme in S.E. Asia, along with the 'forest margin' and the 'sloping lands' agro-ecosystems.

As a first step in developing a program of research, an inventory of the agro-ecosystems is made in which Imperata plays a major role. In an international workshop in January 1995 the various alternative land use systems for Imperata grasslands will be discussed, emphasizing small-holder agroforestry, as well as the possible reclamation pathways and the (changes in) government policies which are needed to facilitate the transformation.

Systems analysis of *Imperata* grasslands

In the issue of reclaiming Imperata grasslands we are dealing with a number of 'levels of complexity' of the systems we are studying. It may help to separate them clearly, so as to be clear about the different 'actors' involved and to guide the formulation of hypotheses for 'further' research.

Fig. 1 gives a first approximation to such a hierarchy :

- the most simple system we are dealing with is the plant *Imperata* in its relations with the abiotic factors, soil and climate.

- the next level considers the cropping system; now the principle actor becomes a farmer and he/she tries to modify the plant community so as to maximize outputs (yields) for minimum costs (inputs: labour, seeds, chemicals etc).

- close to the 'cropping system' level, we consider the 'farming system', which includes the choices of the farmer between cropping and other on-and off farm activities.

- at the next level, we introduce the notion of 'government', as a body which modifies the input/ output relations of the farm, by subsidizing or by imposing taxes and by more directive measures such as laws. In dealing with the farmer, the government is also modifying the relations between the farmers and other land users.

- at a higher level, but probably not directly relevant for our project, we can see how 'governments' interact with neighbouring ones.

In the project we are dealing with 'reclamation' or any similar word indicating a change in land use from the present situation of an *Imperata* grassland to another, probably more intensive, type of land use. To analyze this change, we have to know the 'present value' of the system to the various land users, the potential value of alternative land uses and the costs of change (Fig. 2). If the difference between future and current 'value' is large, the change may be brought about irrespective of the costs. If the increase in value is relatively small, the costs of transformation will become critical.

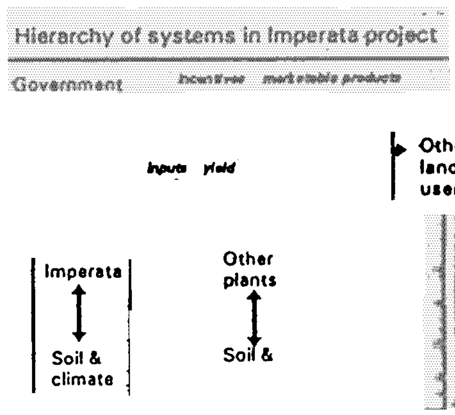


Figure 1. Hierarchy of systems considered in the project on utilization of *Imperata* grasslands

One step further, we can consider a number of 'pathways' which start at *Imperata* grassland and lead to more intensive land use, be it a forest plantation, an other plantation, a smallholder agroforestry system or a system based on food crops only (Figure. 3).
In the reclamation a number of steps have to be taken :

1. the *Imperata* should be removed/reduced in vigour.

2. fire should be prevented (or tolerated) and,

3. the desired plants should be able to grow, which may require an improvement of soil fertility.

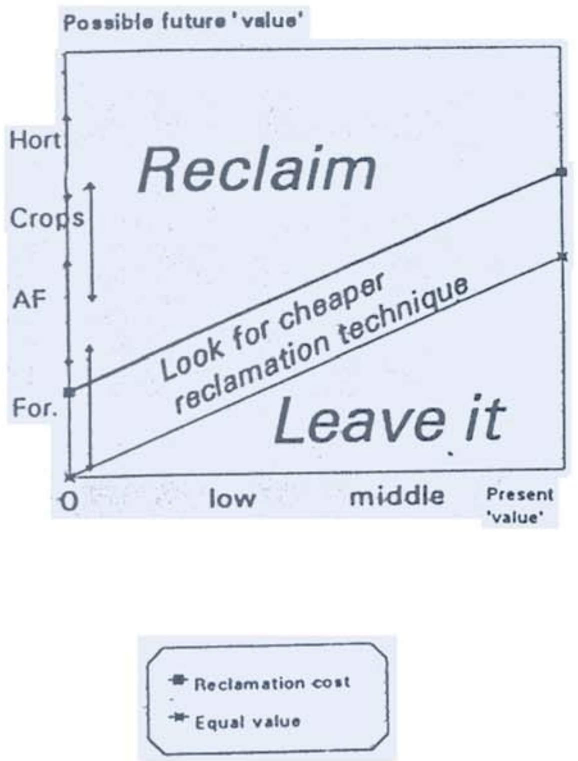


Figure 2. Simple decision scheme to evaluate whether or not 'reclamation' of *Imperata* grasslands

For the pathways three starting points can be distinguished, representing the initial control step

1A. Herbicides such as roundup,
1B. Tillage, by manual, animal or tractor power,
1C. Shade, cast by cover crops or trees. The shade methods are closest to a natural succession, which may start as soon as fire is absent from the land.

Table 1 Tentative evaluation of three methods for dealing with Imperata as a first step in reclamation.

	Time needed for effect	Labour needs	Inputs
Herbicides	week		
	year		

As indicated in Table 1, a tentative evaluation of the three methods may consider time, labour and external inputs (labour may have to be paid for as well). The herbicide pathway is the quickest and may take 1 week only, if the herbicide is sprayed in a young regrowth stage (after slashing, crushing or burning); under less favourable conditions spraying has to be repeated. Tillage may need 2 or 3 operations and may take a month; best results are normally obtained in the dry season when the rhizomes are left to dry on the surface. Biological methods, based on cover crops or shade trees need time: at least 2 or 3 months of a dense shade is needed to have a real effect on the vigour of *Imperata* and it may take time for the canopy to develop. Fast growing leguminous cover crops (*e.g. Mucuna, Calopogonium* and *Pueraria*) can be used, but may need an initial slashing, crushing or burning. A number of trees can be used, but unless the trees are fire tolerant, they depend on fire control or on luck. Natural succession would take care of the *Imperata* if there is a sufficiently long period without fire. Succession is most rapid along a forest margin and may start with creeping vines (*Mikania*) or forbs (*Chromolaena*), followed by shrubs and trees (*Vitex, Peltophorum, Schima* and others). Explicit stimulation of this biological pathway is poorly documented, but may be the lowest cost (although slowest) option.

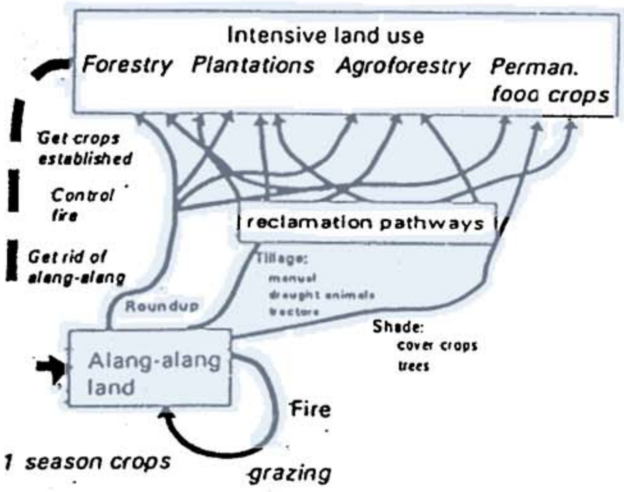


Figure 3. Patways in 'reclaiming' *Imperata* grasslands

Figure 4 shows the two main trade-offs in choosing the method: time versus effort (Y-axis) and nature of the efforts: labour versus external inputs (X-axis).

After the first step in Fig. 3, the pathways diverge, and potentially each destination can be reached from each starting point. It may be worthwhile to describe actual pathways taken, in some detail and see how they depend on soil or other conditions. For example, when fire tolerant tree species are introduced in a grassland, the need for fire control will be less.

Fig. 3 also indicates that the more intensive land use systems can revert back to the alang-alang stage, and that the alang-alang land may be part of an short term cropping cycle (based on slash and burn) or used for grazing/hunting on the basis of new regrowth after a burn. In fact, preventing the re-occurrence of *Imperata* is crucial for any reclamation effort aimed at long term land use. The major way of achieving this is to keep the cropping system sufficiently dense, at least during the major part of the year to prevent reestablishment of the grass.

The stage is now set for looking at the next level of complexity at which pathways and destinations farmers actually choose, depending on their social background and economic environment (Fig. 4). In fig. 5 a number of factors is mentioned which probably play an important role in decisions about the pathways to be used for reclamation, if at all farmers perceive an other land use as more profitable to them then the current *Imperata* grassland. The evaluation of costs and benefits of reclamation by farmers will probably depend on the market for inputs and products, on the presence of cattle (which determines whether or not ploughing is an option), on the cultural background (previous farming experience) of the farmer and on the security of land tenure (be it based on law or adat). Investments in long term productivity of the land probably require secure tenure, otherwise farmers may be expected to go for short term benefits only. Decisions on whether to reclaim *Imperata* grasslands or not, will also depend on the availability of other options: the accessibility of other land, options for off-farm employment and the prospects of migration to new sites with better land. If the choice is migration the cycle of land degradation from forest to wasteland is complete.

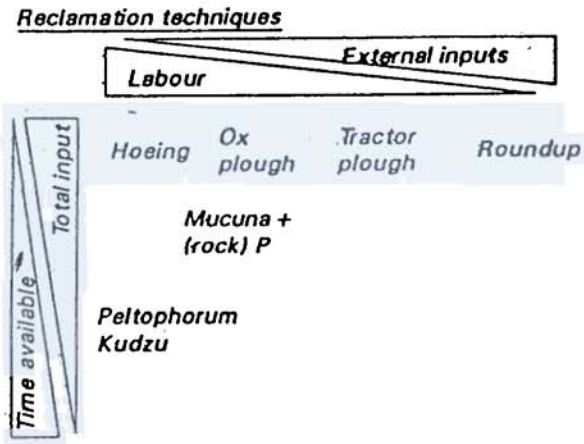
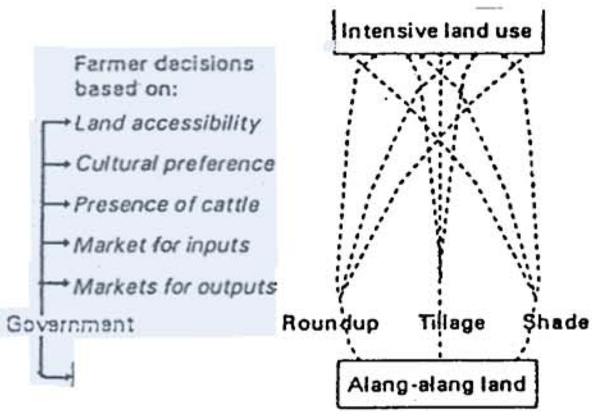


Figure 4. Simple Classification sheme for the first step in reclamation efforts : The Y axis indicates the time needed and the total effort, the X-axis indicated the nature of these efforts, based on labour and/or external inputs.



At the next level, we can then see how government actions can modify farmer's choices, by influencing markets for inputs and outputs, by stimulating the presence of cattle, by spreading information, by clarifying land tenure rules and by modifying the perspectives for other options, including migration.

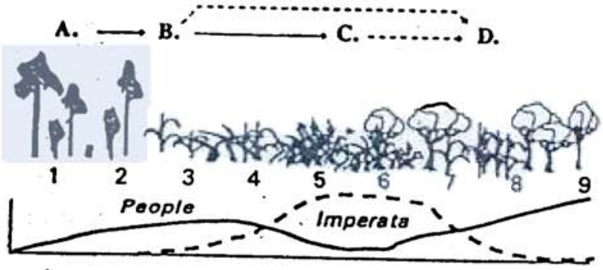


Figure 6. Tentative strages in land use intensification in the humid forest zone : A. Forest, shifting cultivation, B. Bush fallow, C. Degraded lands/*Imperata* grasslands, D. Permanent land Use (agroforestry)

Figure 6 gives a tentative scheme of the evolution of land use systems in the humid forest zone: from primary forest (A) (via logging) into shifting cultivation and bush fallow systems (B) (where local population pressure increases and reduces fallow periods). From here there are two possibilities. either into *Imperata* grasslands (C) and a reduction of population density (people move on to create a new forest margin elsewhere), or into the development of more permanent tree-based production systems (D). The major questions are whether development D is possible from stage C and whether or not stage C can be avoided (from B straight into D).

HYPOTHESES FOR FURTHER RESEARCH

Now we can consider hypotheses for the *Imperata* project, and gradually build up from a biophysical to a policy scale. The hypotheses can be classified under four headings: addressing the issue of future versus present land use, and addressing the issues of reclamation pathways, each from a biophysical (technical) and from a socio-economic value point of view.

Biophysical potential of land currently under Imperata

Hypothesis 1a
A distinction can be made on biophysical grounds between land where more intensive/ productive land use is possible and land where *Imperata* grasslands are the only/ best land use.

Rationale :
In areas where the land capability is low, we don't have to consider any further steps. In many areas, however, *Imperata* grasslands occur on soils which allow more intensive use. The hypothesis claims that a distinction between these cases can be made on biophysical grounds, which can be modified by farmer value systems (see 3). Farmers probably have developed relevant systems for evaluating land in this respect. Existing soil classification and land evaluation schemes may give additional clues. Such a scheme may also consider how the *Imperata* grasslands originated (because land was abandoned due to low yields ?) and to which extent soil conditions have been improved under the *Imperata* fallow. Considerable investment in soil fertility (e.g. by rock-P application) can improve the scope for *Imperata* rehabilitation.

2. Biophysical pathways for reclamation

Hypothesis 2a
Imperata reclamation pathways are based on chemical or physical destruction of the plant, by using herbicides or tillage, or on a gradual hading out by other plants. All pathways have to deal with fire risks and have to provide the conditions for other plants to grow.

Hypothesis 2b
Biological pathways have a clear disadvantage in time required, but this can be compensated if it is a low-cost and low-labour technology; fire tolerance is a requirement to meet these criteria.

Rationale :
The classification of reclamation pathways in Fig. 3 is tentative. Further descriptions of actual pathways are needed to elaborate the scheme and test its usefulness.

3. Farmer evaluation of potential versus actual land use

Hypothesis 3a
Farmer evaluation of both present and possible future value of the land presently under *Imperata* is based on :

- (perceived) security of land tenure,
- (perceived) market for possible products,
- presence of cattle and need for grazing land
- household needs and resources,
- (perceived) chances for off-farm employment and migration.

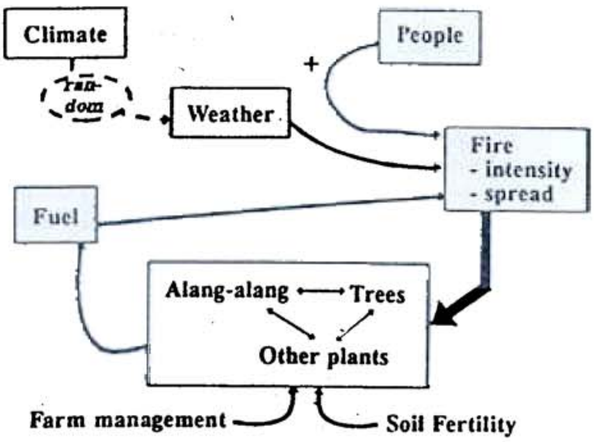


Figure 7. Schematic reletions in cause and effect of bush fire

Hypothesis 3b
Farmers will only consider reclamation of *Imperata* grasslands if no other land is available.

Rationale :
Farmers will only consider rehabilitation if the present value of the land to the users is lower than the possible future value. These present and future 'values' to the farmer do not only depend on the biophysical characteristics of the land (considered under 1.), but probably also on a number of factors as mentioned in the hypothesis. Reclamation of land which was first left to *Imperata* should address the reasons for abandoning it previously.

4. Farmer choices among reclamation pathways

Hypothesis 4a
If the possible future value under other land use is much higher than the present one, existing 'high input' technologies based on (tractor) tillage and herbicides can be used and are easily affordable.

Hypothesis 4b
Low-cost reclamation techniques, e.g. by cover crops and fire tolerant trees, become important in those situations where the 'future value' of land use is only moderately higher than the present one.

Hypothesis 4c
Farmers will only choose a biological pathway if sufficient time is available to planning ahead.

Hypothesis 4d
If animal draught power is available, tillage is the obvious reclamation method, provided that the dry season is long enough; in this situation *Imperata* grasslands can be part of a regular fallow pattern.

Hypothesis 4e
Fire control as second step in a reclamation pathway requires social coherence in a groups of land users.

Rationale :
Reclamation pathways chosen will vary among land users, based on resources and (perceived) options. The 'niche' for agroforestry techniques in land reclamation is probably restricted on one hand by the economic possibilities for high external input farming (hypothesis 4a) and on the other hand by the required time frame (hypothesis 4c). Some of the steps involved in the biological reclamation pathway by cover crops or trees are listed in table 2.

5. Need for fire control

Hypothesis 5a
Fire control at the community level is a pre-requisite for *Imperata* reclamation, especially in the first stages;

Hypothesis 5b
Fire control based on local institutions is much more effective than that based on government rules and regulations.

Rationale :
Fires are based on the presence of inflamable material (fuel), dry conditions (weather) and people who can either control the fire or stimulate it, for various reasons (Fig. 7). In *Imperata* grasslands there is sufficient fuel for fires in the dry season, and several groups of people may have interests in spreading fire. Biological succession and/or intensification of land use is hampered by fires, as most other plants are not as fire-tolerant as *Imperata*. Fire control can be attempted at a large scale by government-level institutions, or can be based on local (village) level institutiuons.

6. Government policies which can influence farmer decisions

Hypothesis 6a
The simplest and cheapest way for a govern-ment to stimulate reclamation of Imperata *grasslands is to provide secure land tenure.*

Hypothesis 6b
On soils with moderate to low land capability investments in improving soil quality (e.g. rock P) can be subsidized as second step. Such subsidies would be more effective than subsidies on the first steps of the reclamation pathway (e.g. on herbicides).

Rationale :

To the society at large a more intensive use of *Imperata* grasslands by farmers in stead of further deforestation (or degradation of logged over forests) is beneficial (lower opportunity costs). As there is a clash between current farmer decision making (leading to land abandonment and migration to new sites) and interests of the society at large, a government program to induce *Imperata* is appropriate. Such a program should be cost effective and can be build on the factors modifying farmer decision making. Hypothesis 6b makes a comparison between a number of possible subsidies: long term effects should prevail over short term ones.

Table 2. Steps to be considered in management of cover crops or trees for biological *Imperata* control

A.	Establish cover crop or tree in *Imperata* grassland	
-	direct seeding.	
-	seeding after initial reduction in *Imperata* vigour:	
	-	after slashing the aboveground *Imperata* biomass,
	-	after burning the aboveground *Imperata* biomass,
	-	after ploughing the soil,
	-	after using herbicides (glyphosate)
	-	soil fertility improvement (rock-P etc.)
B	Time needed for control of *Imperata*	
C.	Slashing cover crops or trees and planting food crops/ commercial trees	
D.	Preventing re-infestation during the cropping cycle	

SOME EXPERIENCES WITH ROTATIONAL ALLEYCROPPING AS SHADE-BASED *IMPERATA* CONTROL STRATEGY

Alleycropping (or hedgerow intercropping) has received considerable attention from researchers throughout the tropics in the past decade, after the first publications in which it was presented as a 'stable alternative to shifting cultivation' (Kang and Wilson, 1985).

The alley-cropping system is related to the bush-fallow system practiced by farmers all over the world in a certain stage of intensification of land use, in which a bushy fallow alternates in time with a cropping phase. In many traditional versions of this system, stumps of the trees survive during the cropping phase and help to reestablish a woody vegetation which can partially restore soil fertility afterwards. Alley-cropping is an attempt to replace this temporal sequence by a spatial zonation, in which the trees play their role in a certain strip in between the crops. In the specific way in which alley-cropping has been promoted *Leucaena leucocephala* hedgerows at 4 m spacing, pruned regularly at 0.5 - 1 m height), it has not lived up to the expectations. This is partly due to unrealistic expectations, partly due to biophysical reasons (a single 'miracle tree' is too vulnerable as shown by the *Heteropsylla* invasion, where water supply is limiting tree-crop competition is too severe, *Leucaena* is poorly adapted to acid soils) and partly to high labour demands for pruning.

At the moment, attention is shifting towards systems which are a bit closer to the bush-fallow system, and which can be termed 'rotational alley-cropping': trees are still grown in hedgerows, but cropping is not continuous; a tree phase alternates a crop phase. During the crop phase, the trees are severely set back by a low-level pruning to reduce competition as well as labour demands for pruning; yet the tree stumps are supposed to survive and allow a quick regrowth of trees after 1-3 years of cropping. Candidate trees for thus system must survive the setback pruning and develop a proper tree canopy when left to grow. If such a system is able to control weeds such as *Imperata* in the fallow stage, the labour costs of pruning may be more then off-set by the time gained for weed control.

Current experiments in North Lampung, in collaboration between Brawijaya University (Malang) and ICRAF test a prototype of this system, based on *Gliricidia sepium* and the local tree *Peltophorum dasyrachis* (local names: Pohon soga, Petaian laut). A long term alley cropping experiment showed that only *Peltophorum* or a system with alternating hedgerows of *Peltophorum* and *Gliricidia* gave consistent yield advantages over a control monoculture crop ((Hairiah et al. 1992; Van Noordwijk *et al.* 1991, 1994). These two trees are also the strongest species as regards long term pruning tolerance (*Erythrina orientalis* and *Calliandra calothyrsus* died back after about 3 and 6 years, respectively). The local tree *Peltophorum* is reasonably fire-tolerant (this probably explains its local dominance in the secondary forest vegetation) and is one of the few trees establishing spontaneously in *Imperata* grasslands.

In 1992 an experiment was started to get the trees growing in an alang-alang grassland, with a minimum of labour and other inputs (transplanted local tree seedlings, a bit of P fertilizer) in a small strip which was manually cleared of *Imperata* (Van Noordwijk *et al.* 1992). In the next two years trees were left to grow. After 1 year the trees had started to reduced *Imperata* vigour, but not sufficiently so, especially in the *Gliricidia* plots the weed *Chromolaena odorata* was partially replacing the *Imperata*. During the second year, tree canopy development continued, but not enough to eliminate the *Imperata*. Tree growth showed considerable variability - in the patches were the tree grew best adequate *Imperata* control was reached after 2 years, but not on the majority of the plots. A fire raged through the plot in the exceptionally dry season of 1994 and provided a true test of the fire tolerance of the trees. All trees of both species are re-sprouting after the fire, but only the *Peltophorum* trees on the best patches (were the fire intensity was probably less due to less *Imperata* biomass) resprout from higher stem positions. Coming rainy season the farmer who is owning the plot will grow rice + maize. One half of the plots are pruned at ground level, the other half at 0.75 cm height, as in the conventional alley cropping system. Fruit trees (Manga and Parkia) will be introduced into the system on the farmer's wish to gradually transform the field into a permanent agroforestry system.

Hedgerow Intercropping

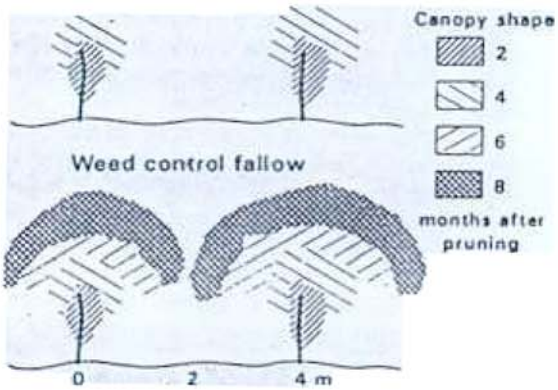


Figure 8. Desirable tree conopy development for a rotational alley cropping system; the tree develops a dense enough conopy to shade out weeds in between cropping episodes.

In the N. Lampung site, leguminous cover crops definitely have a potential from a biological point of view, esp. where *Mucuna pruriens* var. *utilis* or the more perennial *M. deeringiana* are used (Guritno *et al.*, 1992; Hairiah *et al.*, 1993), but farmer acceptance of these options is low, except where farmers value the *Mucuna* for their seeds (Tempeh benguk).

The experience so far suggests that either more effort has to be made to speed up tree establishment, or a higher initial tree density is needed for this system. There appears scope, however to explore the continuum of 'improved fallows' as sequential agroforestry system and 'hedgerow intercropping' as spatially zoned, completely simultaneous system.

The use of an initial tree cover for reclaiming the grasslands and facilitating the growth of other, commercially more valuable tree species may be further explored as well. It has some basic similarities with the way in which farmers in West Lampung have found a way to simulate natural succession and establish man-made dipterocarp forest of *Shorea javanica* (Damar mata kucing): they start with a ladang, have a shrub stage (coffee, pepper, *Gliricidia*) and gradually develop a tree canopy (Michon and de Foresta, 1994). This model of agroforestation cannot be directly applied to the harsher conditions of the acid ultisols on the peneplain of Sumatra, but there is scope for similar systems, if only the time can be bridged until these systems become sufficiently productive.

Acknowledgements

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