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INJURIES ON SEEDLINGS CAUSED BY POTENTIAL WEED IN TROPICAL RAIN FOREST REGENERATION AREAS

KERUSAKAN PADA ANAKAN POHON OLEH GULMA POTENSIAL DI AREAL PERMUDAAN HUTAN HUJAN TROPIK

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INTISARI

Penelitian ini bertujuan untuk menilai kerusakan pada anakan Shorea *spp. yang disebabkan oleh gulma pada areal permudaan hutan hujan tropik di Jambi. Empat sistem permudaan yang digunakan adalah sistem tanam jalur menggunakan tumbuhan penaung (*Acacia mangium, Paraserianthes falcataria *dan* Gmelina arborea*), tanam baris, sistem rumpang dan permudaan alami sebagai kontrol. Penilaian kerusakan didasarkan atas bagian anakan pohon yang terhambat gulma.*

Hasil penelitian menunjukkan bahwa anakan Shorea *dapat menderita berbagai tingkat kerusakan oleh gulma, tergantung jenis gulma yang menghambat dan bagian tanaman yang terhambat. Dominasi jenis gulma dan kerusakan yang ditimbulkan ditentukan oleh tingkat pembukaan tajuk pada sistem permudaan yang digunakan. Gulma penutup tanah sangat mendominasi areal permudaan dengan tajuk terbuka dan menimbulkan kerusakan sampai 55,27% yang dijumpai pada jalur antara* G. arborea *dan* P. falcataria, *sedangkan gulma memanjat dan menjalar menjadi dominan pada pembukaan tajuk sedang. Gejala kerusakan pada anakan* Shorea *yang ditanam di bawah tumbuhan penaung ditentukan oleh jenis tumbuhan penaung dan kerapatan tanamnya. Penggunaan tumbuhan penaung bertajuk jarang, misalnya* P. falcataria, *tidak mampu menekan gulma penutup tanah, sebaliknya di bawah* A. mangium *yang terlalu rapat masih dijumpai gulma memanjat dan merambat.*

Kata kunci: gulma, Shorea, *sistem penilaian*

ABSTRACT

The experiment aimed to assess the injuries on *Shorea* seedlings caused by weed in artificial regeneration of tropical rain forest in Jambi. Four planting systems, strip nurse planting (using *Acacia mangium*, *Paraserianthes falcataria* and *Gmelina arborea)*, line planting, gap planting and natural regeneration, were used. Seedling injuries were assessed based on part of seedling suppressed

Results indicated that *Shorea* seedling suffered from varying degrees of injuries, depending on weed species and part of the seedling suppressed. The dominance of weed and damage intensity were determined by the level of canopy opening on the planting systems. Ground cover dominated rapidly in open canopy, causing up to 55.27% injuries on the seedlings in the strips of *G. arborea* and *P. falcataria.* Whereas creepers and vines became dominant in moderate canopy opening. The injury of *Shorea* seedling planted under nurse tree was determined by the species and planting density of nurse tree used. Light canopy nurse tree such as *P. falcataria* failed to suppress ground weed, but in the contrary, *A. mangium* with heavy canopy still allowed creepers and vines to grow.

Key words: weed, *Shorea*, scoring system

INTRODUCTION

With the increasing public concern about environment, many people have come to think that any disturbance of forest damaging the integrity of the ecosystem, will have further effect on the global warming. Forest degradation due to any reason has been blamed as the major cause of increasing CO_2 in the atmosphere. The question of how much carbon can be fixed and stored in the forest has also been a serious question to be answered. Carbon is lost from forest primarily as respiratory CO_2, and some of the carbon released as CO_2 is reabsorbed by photosynthetic process (Kimmins, 1996).

Tropical rain forests, which have been acknowledged to function in a vital role as environmental regulator, produce higher carbon than other ecosystems. Firstly, the trapping and reabsorption of night time respiratory CO_2 is more efficient in tropical rain forests than in diminutive plant communities. Secondly, carbon fixation in tropical rain forest resist longer time than in other ecosystems (Bernade, 1992). However, it is important to note that the potential of the forest to store carbon is efficient only as long as the forest is undisturbed.

Tropical rain forest as natural ecosystem can not be defined only in terms of steady-state or equilibrium concepts. The forest still has its integrity as long as its structure and species composition, its rate of ecological processes, and its ability to resist change from disturbance or stress are still within the characteristic range perform by that ecosystem (Kimmins, 1997). Species of climbers, vines and ground cover plants under natural condition, have their role to maintain the steady-state of the forest. However, as the forest structure changes due to any reason, they may turn into potential weed, mainly due to their characteristic growth habits and aggressiveness to dominate sudden canopy opening (Sumardi & Widyastuti, 1999). That is why even the forest is subject to exploitation, which will happen if the harvesting is conducted in a way that impairs the integrity of the ecosystem recovery from disturbance, the integrity of the forest ecosystem will be rebalanced.

In line with the concept, Kansai Environmental Engineering Center - Gadjah Mada University (KEEC-GMU) research collaboration has established a 4 year plant of tropical rain forest in Jambi. This experiment aimed to evaluate the incidence of weed suppression, particularly the species of climbers, vines and ground cover plants on seedlings as affected by silvicultural practices. Descriptive scoring system proposed by Mangold (1997) for Forest Health Monitoring was modified to evaluate the incidence of seedling damage.

MATERIALS AND METHODS

Time and location. The experiment was held in the forest rehabilitation area in Jambi, in January 1999, where different planting systems of *Shorea* spp. were applied. When this evaluation was made, the seedlings had been planted for 4 years. The trial plantation was established in the Research and Education Forest of Gadjah Mada University (GMU) located at the middle district of Batanghari river basin, Jambi (102^0 30". $1^0$33").

The plots. Sampling plots were set up in four different planting systems. The form, size and number of plots established were purposive to the variation and nature of existing planting systems. In line and strip planting systems measurement were made in line plots, whereas in gap and nurse planting system square plots were used.

1. Strip planting with nurse planting system

Dipterocarp seedlings were planted within the rows of nurse tree of exotic tree species. The beneficial of nurse trees relate primarily to their ability in providing appropriate shading and weed control for successful growth of dipterocarp seedlings. Three species of nurse tree [*Acacia mangium* Willd., *Paraserianthes falcataria* Roxb., and *Gmelina arborea* (L.)], were planted in planting units consisting of 4 rows each, in two block areas with 3 replications (Figure 1). The nurse plants were planted in January 1994, and dipterocarp seedlings were planted in February 1995. Weedings were carried out together at the same time when seedling growth evaluations were made [in June & November 1995, June & November 1996, and June 1997 (Hardiwinoto, 1996)]. Center row of the three rows of dipterocarp seedling in all strips of nurse plants was selected as the sampling units in this experiment.

2. Line planting system

a. Under natural forest. The existing planting systems consist of two different sets of 500 m lines of dipterocarp plantation under natural forest, with 3 lines each. In the first type, the distance between rows is 5 m, whereas in the second type the distance between rows is 10 m. Two separate sampling units of 100 m located in the opposite edges of each line, were used for assessing weed suppression.

b. Under Macaranga. In this planting system, dipterocarp seedlings were planted in rows with 5 m distance between row. Two sampling units, which consist of 3 lines each, located on the opposite end of planting area were used for weed suppression assessment of the seedling.

3. Gap planting system.

In this experiment three different size of gap planting systems were used (Okimori *et al.*, 1996), i.e. 40 m × 40 m, 20 m × 20 m and 10 m × 10 m. All dipterocarp seedlings planted in the gaps with 2 replications were recorded for the damage of seedling caused by weed attack.

4. Natural regeneration.

Weed attack assessment of dipterocarp seedling in natural regeneration was evaluated in the existing permanent regeneration plot. Nine square sub-plots (5 × 5 m), no. 1; 5; 10; 50; 55; 60; 91; 95; 100, were used to evaluate the seedling damage.

Procedures. Injuries on forest regeneration were recorded on the survived seedling and small sapling of Shorea. The injuries were recorded if, by definition, the seedling was killed or affected in the long term survival. The seedling and small sapling were observed from all sides and the damage was recorded. Injuries were classified based on the modes by which the seedling was suppressed by weed. The classified weed are (A) climbers and vines, (b) ground weed, and (C) shading effect of other plants.

Within any given type of weed, the hierarchy of injury follows the numeric order of attack types possible for that location. The numeric order denotes decreasing significance as the code number goes down, *i.e.*, damage 04 is more significant than damage 01.

Determination and coding damage by location. For this experiment, the injury was recorded if, by estimation, could kill the seedling or affect the long term survival and growth condition of the seedling. This definition and the coding system of weed attack was developed based on the damage and catastrophic mortality assessment in Forest Health Monitoring (Mangold, 1997). The descriptive key developed in this experiment are as follows:

Code	Type of damage
A Damage on seedling caused by climbers and vines	A1 No weed suppression A2 Weed suppression other than main stem A3 Weed suppression the main stem of seedling A4 Most part of seedling is suppressed
B Damage on seedlings caused by ground weed	B1 No ground weed competition on seedling B2 Small part of seedling is covered by ground weed B3 Most part of seedling is covered by ground weed B4 Seedling died or seriously suppressed by ground weed
C Damage on seedling caused by shading of other plant	C1 No shading effect of other plant C2 Shading effect causing "etiolation respond" C3 Shading effect causing "serious growth suppression" C4 Seedling died due to shading of other plant

RESULTS AND DISCUSSION

Climbers and vines. Liana is represented by group of herbaceous woody plants with climbing habit that form a specific layer in tropical rain forest (Kimmins, 1997). Its light-demanding growth type, makes this group of plants invade open canopy in tropical forest. In general the weediness of plant can be attributed to its abundant, precious (within first year), year-round seed production, lack of pollinator specificity, its ability to resprout after cutting or burning, the build up of a persistent seed bank in the soil, its drought tolerance, its ability to form dense impenetrable thickets and its self-compatibility which means that it can spread from seed produced by an isolated tree. Climbing habit is another weediness attribute for plant.

Results of this experiment showed that climbers and vines were found in all planting systems causing various degrees of injuries on seedling. It was noted from table 1 that the proportion of seedling damage by climbers and vines varied depending on the planting systems applied. They attacked the main stem, branches and/or foliage of seedling. In natural regeneration, 14.28% of total seedlings observed were attacked by climbers on their main stem. No climber attack on parts of seedling other than main stem was found. Changes of forest structure creating canopy opening may stimulate the incidence of damages caused by climbers and vines. In gap and strip planting systems under natural forest, climbers and vines attacked 25.53% and 24.49% of the total seedlings respectively. In the modified vegetation structures, climbers and vines grew more vigorously and started to attack branches and foliage of seedlings.

In planting system started from open areas, the incidence of climbers and vines varied depending upon the shading manipulation. In nurse planting systems, an amount of 21.04% to 35.30% of the total number of seedlings were attacked by climbers, with the biggest attack was observed in the lines between *A. mangium* and *P. falcataria* while the lowest was found under lines between *G. arborea* and *P. falcataria*. In planting system under *Macaranga*, the incidence of climber attack was 14.82%, which was almost the same to that of natural regeneration. Open canopy which creates more light in the forest floor seemed to be the main factor causing the increase of climbers and vines attack. Climbers and vines are light demanding plants and therefore grow vigorously in more open canopy (Salisbury & Ross, 1978). The more the silvicultural practice creates canopy openings, the higher the climbers and vines attack was found.

Table 1. Type of weed suppression by climbers on the seedling of *Shorea* spp. in different planting systems

Planting system	Weed suppression type (%)*			
	A1	A2	A3	A4
Nurse planting :				
a. *A. mangium/ A. mangium*	71.78	7.42	8.01	11.88
b. *A.. mangium/P.falcataria*	64.70	11.76	10.58	12.94
c. *P. falcataria/ P. falcataria*	70.32	9.03	12.90	7.74
d. *P. falcataria/ G. arborea*	78.94	6.57	9.21	5.26
e. *G. arborea/G. arborea*	77.14	5.00	6.42	6.42
f. *G. arborea/ A. mangium*	71.66	6.66	8.33	8.33
Average	72.42	7.74	9.39	8.76
Line Planting :				
1. under natural forest				
a. Type 1	81.53	2.83	10.63	4.96
b. Type 2	69.42	0.00	24.79	5.78
Average	75.49	1.41	17.71	5.37
2. under macaranga	85.18	1.85	12.96	0.00
Gap planting :				
a. 20 m × 20 m	86.50	0.79	10.31	0.02
b. 30 m × 30 m	60.78	7.18	17.64	14.37
c. 40 m × 40 m	73.68	4.51	14.66	7.14
Average	73.65	4.16	14.20	7.17
Natural regeneration	85.71	0.00	14.28	0.00

*Notes: A1: No weed suppression
A2: Weed suppression other than stem
A3: Weed suppression on stem
A4: Weed suppression all parts of seedling

The level of damage on seedling caused by climbers is dependence upon part of the seedling attacked and proportion of seedling twisted. Figure 2 illustrates the attack of climbers and vines on the stem part and other part of seedling. Once the climbers attack the stem part of seedling, growth suppression developed. Depending on the vigorousness of the climbers, the suppression could develop further into more serious attack.

Sumardi & Widyastuti (1998) found that most of the liana in the area, have specific growth habits as woody climbers and vines that sometimes kill their host. They also found that many lianas were the species of legumes performing root nodulation and nitrogen fixation (Sumardi & Widyastuti, 1996). Therefore, it is important to note that lianas which commonly treated as weed causing potential damage, also play an important role as major nitrogen input agent in the forest.

Ground cover. Colonisation of undergrowth is a process of two components: invasion and survival. The high rate of invasion and survival are important attributes for vine and other ground cover to be a potential weed. Ground cover consists of species which tend to have high rates of invasion because it produces very large numbers of reproductive propagules and because it has an efficient means of dispersal (Kimmins, 1996).

Results of observation showed that ground cover, dominated by vine, simultaneously grows in tropical rain forest where open canopy is created. Depending upon the level of domination, ground cover may cause varying degrees of growth suppression on seedlings particularly during their early establishment (Table 2).

Vines grew rapidly and dominated open space of planting areas only within several months, and created physical competition for light to seedling establishment. The sooner the ground cover dominated the area, the more severe the competition on the seedling will be. Figure 3 illustrates serious growth suppression on seedling caused by ground cover.

It was concluded that planting systems initiated with open canopy gave more room for ground cover to grow. However, domination of ground cover failed to occur in the planting system under canopy gaps up to 40 × 40 m. In nurse planting systems, more than 26% of the planting areas were dominated by ground cover. *P. falcataria* and *G. arborea* did not grow well in the area and failed to perform appropriate shading provision for dipterocarp seedlings. In these planting areas species of ground cover grew vigorously and suppressed seedling establishment. Once the seedlings experienced serious growth suppression by ground cover, it was difficult for them to recover, unless release cutting is applied.

Where the objectives of plantation require that a mid-seral tree species form the next tree species, it is obviously desirable to disturb the forest sufficiently to create physical and biotic conditions favoring the growth of that species. This requires the creation of an early seral-mid seral microclimate, tolerable levels of competition and a mid-seral forest floor-soil condition (Kimmins, 1996).

Shading. Nurse plant may be attributed as the shading factor. *A. mangium* and *G. arborea* which by nature having heavy canopy, when planted in high density will create potential shading effect beyond the capacity of dipterocarp seedling to tolerate. *P. falcataria* in the other hand have light canopy which enable sunlight to pass through.

Table 2 : Type and severity of seedling injuries of *Shorea* spp. caused by ground cover

Planting system	Weed suppression type (%)			
	B1	B2	B3	B4
Nurse planting system				
a. *A. mangium/ A. mangium*	72.27	17.82	8.91	0.99
b. *A.. mangium/P.falcataria*	52.94	27.05	20.00	0.00
c. *P. falcataria/ P. falcataria*	56.12	11.61	32.25	0.00
d. *P. falcataria/ G. arborea*	44.73	15.78	39.47	0.00
e. *G. arborea/G. arborea*	61.70	11.34	26.95	0.00
f. *G. arborea/ A. mangium*	73.33	15.00	8.33	3.33
Average	60.18	16.43	22.65	0.72
Line Planting :				
1. under natural forest				
a. Type 1	89.36	7.80	2.83	0.00
b. Type 2	99.17	0.82	0.00	0.00
Average	94.26	4.31	1.42	0.00
2. under Macaranga	90.74	5.55	3.70	0.00
Gap planting :				
a. 20 m × 20 m	100.00	0.00	0.00	0.00
b. 30 m × 30 m	95.42	3.92	0.65	0.00
c. 40 m × 40 m	97.18	2.44	0.37	0.00
Average	97.53	2.12	0.34	0.00
Natural regeneration	85.71	0.00	14.28	0.00

*Notes: B1: No ground weed competition
B2: Small part of seedling is covered by ground weed
B3: Most part of seedling is covered by ground weed
B4: Seedling died or seriously suppressed by ground weed

The density and species of nurse plants were other factors determining the domination of ground cover in nurse planting system. Light canopy of *P. falcataria* allowed more light to pass trough compared to heavier canopy of *A. mangium* and *G. Arborea.*

Changes of forest condition resulted from planting systems application may cause not only significant increase of weed damage but also pest and diseases attack. Widyastuti & Sumardi (1999) found that quite a number of dipterocarp seedlings planted in the same planting systems suffered from pest and disease damage.

Assessment of injury status of early growth, *i.e.* the growth of seedling and sapling, enable prediction of the tree and stand growth and development. Therefore, survival and growth quality during the seedling and sapling growth stage need to be assessed specifically. The coding system developed in this experiment should be periodically checked for long-term detection of change, so that the over all assessment could be formulated and standardized.

Table 3. Shading suppression on the seedling of *Shorea* spp.

Planting system	Weed suppression type (%)*			
	C1	C2	C3	C4
Nurse planting :				
a. *A. mangium/ A. mangium*	90.59	1.48	7.92	0.00
b. *A.. mangium/P.falcataria*	76.47	3.52	15.29	4.70
c. *P. falcataria/ P. falcataria*	61.29	3.22	35.48	0.00
d. *P. falcataria/G. arborea*	44.73	2.63	52.63	0.00
e. *G. arborea/G. arborea*	66.42	4.28	29.26	0.00
f. *G. arborea/ A. mangium*	90.00	1.66	8.33	0.00
Average	71.58	2.79	24.81	0.78
Line Planting :				
1. under natural forest				
a. Type 1	98.58	1.41	0.00	0.00
b. Type 2	100.00	0.00	0.00	0.00
Average	99.29	0.70	0.00	0.00
2. under macaranga	81.48	5.55	12.96	0.00
Gap planting :				
a. 20 m × 20 m	10.00	0.00	0.00	0.00
b. 30 m × 30 m	99.34	0.00	0.65	0.00
c. 40 m × 40 m	98.30	0.37	1.31	0.00
Average	99.21	0.12	0.65	0.00
Natural regeneration	76.19	14.28	5.55	0.00

*Notes: C1: No shading effect
C2: Light shading effect
C3: Moderate shading effect
C4: High shading effect

Figure 1. Nurse planting system of *Shorea* plantation under
(a) *Acacia mangium,* (b) *Gmelina arborea*

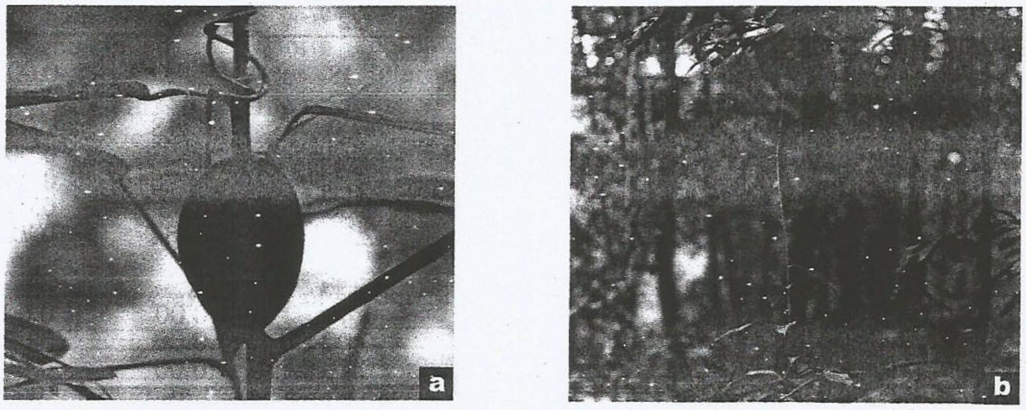

Figure 2. The modes by which the weed suppression seedling
(a) On the main stem of seedling, (b) On the branch of seedling

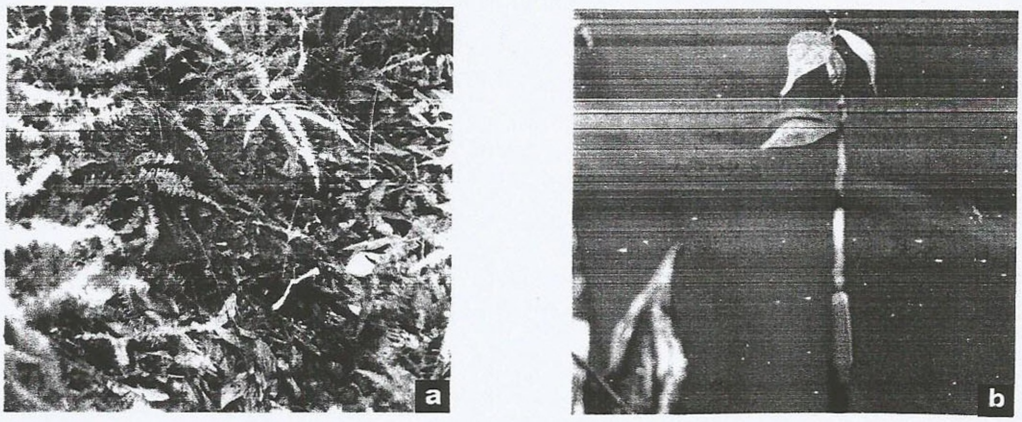

Figure 3. Growth suppression on seedling caused by ground cover
(a) Serious growth suppression on seedling, (b) Close observation of growth suppression

CONCLUSIONS

1. The coding system developed in this experiment could accommodate and quantify the injury of *Shorea* spp. seedling in the field, and the scores are repeatable. It is possible using this coding system to evaluate growth development of seedling and predict the growth quality of the forest stand.
2. Higher seedling injuries recorded in all planting systems compared to that in natural forest indicated that the planting systems did not provide optimum habitat yet for *Shorea* spp. seedlings.

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REFERENCES

Bernade, M.A. 1992. Global Warning ....Global Warming. John Wiley, New York, 317 pp.

Hardiwinoto, S. 1996. Shading Effects of Some Tree Species on the Growth of Some Dipterocarp Species. *Annual Report of Joint Research GMU-KEEC 1995/1996.*

Kimmins, J.P. 1996. *Forest Ecology. A Foundation for Sustainable Management.* Prentice-Hall, Inc. New Jersey. 596 pp.

Mangold, R. 1997. *Forest Health Monitoring. Field Methods Guide.* USDA Forest.

Okimori, Y., J. Kikuchi, S. Hardiwinoto & T. Watanabe. 1996. Gap Plantation of Dipterocarps in Jambi. *Proc. of the Seminar on Ecology and Reforestation of Dipterocarp Forest.* Fac. of Forestry, GMU and KEEC Japan.

Salisbury, F.B. & C.W. Ross. 1978. *Plant Physiology 2nd Edition.* Wodsworth Publishing Co, Inc. Belmont California. 422 pp.

Sumardi & S.M. Widyastuti. 1997. The Distribution and Specific Activity of Nitrogen Fixing Plants in the Low-land Dipterocarp Forest in Jambi, Sumatra. *Proceed. FORTROP'96.* Kasetsart University, Bangkok, Thailand.

Sumardi & S.M. Widyastuti. 1999. Nitrogen Fixing Lianas and Growth Habits in Tropical Rain Forest. *In* Sabarnurdin, S, Suhardi, & Y. Okimori (eds). Ecological Approach for Tropical Forest Rehabilitation. *Proceed. of National Seminar. Faculty of Forestry, Gadjah Mada University, Indonesia.*

Widyastuti, S.M. & Sumardi. 1999. Assessment of pest and disease status of early growth of *Shorea* spp. *Forestry Bulletin* 40 (*in press*).